MILK

ITS PRODUCTION AND USES

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WITH CHAPTERS ON DAIRY FARMING, THE DISEASES OF CATTLE, AND ON THE HYGIENE AND CONTROL OF SUPPLIES

BY

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WITH NUMEROUS ILLUSTRATIONS PREPARED FROM PHOTOGRAPHS, ETC.

LONDON

CHARLES GRIFFIN & COMPANY, LTD.

EXETER STREET, STRAND

1903

PREFACE

As a medical man much engaged in Public Health work and as Sanitary and General Scientific Adviser to the largest of the Metropolitan Dairy Companies, I have naturally given much attention to all questions connected with the production of milk and the control of the trade. Having contributed an article on milk to the "Encyclopædia Medica," I was advised by several friends occupying influential positions in the Public Health service to expand it into a small volume, which, without attempting to cover the ground of the "Complete Grazier" or to rival the exhaustive "Dairy Chemistry" of Richmond, should give within a small compass and in a convenient form information on every question that might arise in connection with the economic, medical, or chemical aspects of the industry. I could easily have extended the book to many times its actual size, but my chief difficulty has been to so apportion the matter as to satisfy each of many and varied interests having nothing in common beyond the fact of their dealing in one way or another with milk. Yet though the whole of the chapters into which it is divided will appeal equally to few, it would be well if every farmer and dairyman knew the ways and means by which milk may

become a vehicle or a factor in the spread of disease and had a rational conception of the nature of milk analysis. The Analyst would be better able to draw sound conclusions from his estimations if he understood the influence of breed, food and season on the composition of milk, and in this, as in so many subjects, the medical man is bound to endeavour to know "something of everything."

Probably the sale will be mainly divided between students at the Agricultural Colleges, Medical Men and those gentlemen in the country who engage on a greater or lesser scale in dairy work, which they follow as a subject of intelligent study rather than as a merely money-making concern, though the lessons taught in the chapters on "Housing of the Cow" and "The Dairy" need to be impressed or forced on the vast majority of cowkeepers in town and country.

I have, of course, availed myself of the information contained in the recognised text-books, as those of Professors Fream, Sheldon, Long, and Warrington, and of the assistance of friends of great practical experience, but I must specially acknowledge my indebtedness to H. Droop Richmond, F.I.C., from whose admirable "Dairy Chemistry" as the best work on the subject I have drawn much of the materials for my chapter on "Milk Analysis," and from whom I have received many friendly suggestions, as I had in years gone by from his predecessor, Dr. Paul Vieth. For the details of bacteriological examinations I am partly indebted to Mr. Pakes, now Bacteriologist to the Government at Cape Town.

While treating with some fulness of butter-making, I have wholly ignored that of cheese, partly because the manufacture has, save in a few special districts, fallen into disuse, and partly thinking it prudent to say nothing on a matter of which I had no personal knowledge.

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BRAXTON LODGE,
GREEN LANES, N.
November 1903

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BREEDS OF DAIRY COWS

THE quantity and the quality of the milk yielded by a herd of dairy cows depend, *inter alia*, on the breed and age of the animals, their food and the shelter afforded them, on the time of year and on the weather. In choosing cows for dairy purposes their milk-producing powers are naturally the first consideration; but, since these are sure to fail after a certain number of years, the aptitude of the breed to fatten for the butcher cannot be wholly ignored, and in districts where the pasture is poor or the climate inclement their ability to give milk and produce flesh on a scanty food-supply and in cold damp weather must also be taken into account.

The **Shorthorn** fulfils all these requirements to a greater degree than perhaps any other, and is consequently a general favourite with English farmers, as well as with those in America, where it is known as the Durham. Its origin is uncertain, but it seems to have been evolved early in the eighteenth century by a judicious intermixture of northern breeds. Its milk, though not so rich in fat as that of several other breeds, is well up to the average, and abundant; while its hardy constitution is a great advantage, since it permits of its being kept, even in winter, in open airy sheds. (Figs. 1 and 2, pp. 3 and 4).

Herefords resemble Shorthorns in many respects; they are remarkably tolerant of exposure to cold and wet, and abortion is rare among them. Their beef is unrivalled, and in some districts they are preferred to Shorthorns. (Fig. 3, p. 7.)

Ayrshires, almost exclusively favoured by the dairy farmers of the Scottish Lowlands, surpass all others in hardiness, thriving on pastures where even a Shorthorn would starve, but nevertheless well repaying care. Their yield of milk is enormous, having been known to reach 1000 or 1200 gallons in the year; it is said to be specially adapted for cheese-making. They are handsome animals, in colour almost always irregularly patched with red and white, holding their heads high, but making so free use of their long horns that it is often necessary to tip these with balls. Their chief fault, however, is that as beefmakers they rank lower than any other breed except the Jerseys. A variety much larger than the ordinary Ayrshire has recently been developed, and the issue of these large Ayrshire cows with a Shorthorn bull combine the fattening properties of their sire with all the good qualities of their Scottish dams. (Fig. 4, p. 8.)

The **Devon**, short-horned, and of a uniform red colour, is not often seen beyond its native county. It yields an abundance of milk very rich in fat, and especially good for making thick cream and butter, while as beef it is fully equal to the Hereford, but, as might be expected, it is not very tolerant of cold, although it does well on poor pasture, few breeds, if any, making better use of their food, whether it be good or bad. (Fig. 5, p. 11.)

The **Sussex** resembles the Devon in its colour and general appearance, although larger and heavier than the latter. Sussex cattle have many good points, but, having been specially valued for draught purposes, have of late years fallen into neglect.

Longhorns, so called, now rarely seen, are easily distinguished from all other breeds by the downward and forward position of the horns parallel with the cheek and jaws. Under the skilful culture of Mr. Bakewell they rose to a high degree of favour throughout the midland and north-western counties, but at present they hold their ground in some of the former only, having been entirely superseded in the latter, including their original home, the Craven district of

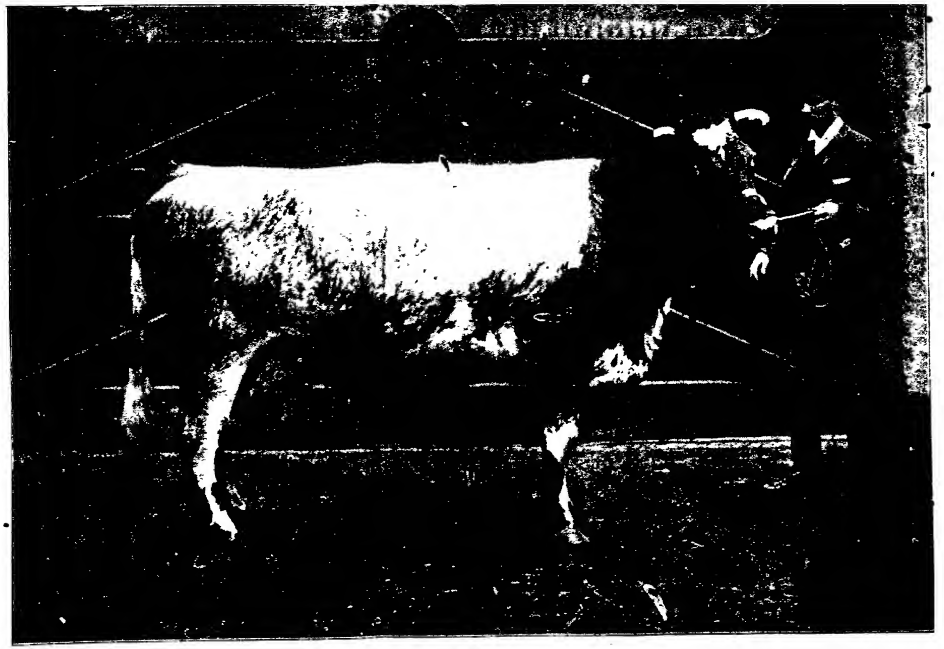


Fig. 1 THE SHORTHORN

Fig. 2 — Shorthorn Heifer

York and Lancashire, by the quicker fattening Shorthorn; while the survivors have greatly degenerated.

The **Highland** and the **Welsh** cattle, of each of which there are two chief branches, one purer and uniformly black, the other a less characteristic because somewhat mixed breed, are doubtless descended from aboriginal wild races of their respective countries, to the conditions of which they are well adapted. Large numbers of Highland and of Welsh cattle are driven every year to the richer pastures of the south, and to the valley of the Severn respectively to fatten for the market. They, the Highland especially, provide the finest beef, but away from their mountain homes, where few other cattle could live, no one would choose them for a dairy, their milk being scanty, although, with good feeding, of fair quality.

Polled, or horniess, cattle constitute a remarkable and anomalous class, the product probably of artificial selection in the distant past, maintained by the persistent elimination of all individuals showing any tendency to atavism in the growth of horns. The **Suffolks** are looked on as typical of the group, and are the most highly esteemed as being the purest bred. They are of a deep blood-red colour, though red or yellow and white and dun coloured individuals are also met with, the last so frequently that the breed was at one time nearly acquiring the name of Suffolk Duns. (Fig. 6, p. 12.) The allied Norfolk cattle are also polled, as are the two Scottish breeds, the **Galloway** (Fig. 7, p. 15) and the **Aberdeen Angus**. (Fig. 8, p. 16.) The latter are the dominant breed on the low coast lands from Inverness to the Frith of Forth, but the Galloways have of late years given place to Ayrshires throughout the county from the old name of which they derive their own, and to Shorthorns in the Lothians and on the English side of the border. They are all good useful animals, alike for the dairy and the stockyard, hardy, and yielding abundance of good milk, and fattening well at the last; while their gentleness, probably the result of their defencelessness, is a recommenda-

tion, since their want of horns precludes their injuring one another at pasture, in the yard, or during transit.

Irish cattle have been for generations crossed with such utter disregard of definite purpose that they are no better than a mongrel crowd, with the one exception of the **Kerries**, whose strongly-marked characters have attracted the attention of intelligent breeders.

The **Kerry**, indigenous to the low "mountains" and moorlands of the south of Ireland, was twenty years ago scarcely known out of its native island, but has of late won a well-deserved popularity, not only in Great Britain, but in America and the Colonies. They exhibit many of the features of a mountain race, being very diminutive, black, with or without a little white, the red of some Dexter Kerries being the result of crossing: hardy, active and able to pick up a living by the roadside, they are, as Professor Sheldon remarks, "pre-eminently the poor man's cow," while their shapely wide-spreading polished horns and short smooth hair, reflecting, in its contrast with the rough shaggy coats of the Welsh and Highland breeds, the more genial climate of their native land, make them really ornamental objects in a park, and they well repay any care bestowed upon them. Their yield of milk is enormous, and in richness it rivals that of the best Jerseys. (Fig 9, p. 19.)

The name of **Dexter** or **Dexter Kerry** is often applied indiscriminately to all Kerry cattle, but belongs strictly to an improved breed raised by Mr. Dexter, agent to Viscount Hawarden, and marked by greater roundness and thickness of form, and shorter legs, so as to have earned for them the reputation of being "beef down to their heels," with the loss of much of the grace and agility of the original type which they are gradually superseding. Whether the change was originated by crossing with a heavier breed, or by a simple process of selection, is not known, though the occasional occurrence of a red colour in Dexters would point to other blood than that of the Kerries themselves. (Fig. 10, p. 21.)

Fig. 3 HEREFORD COW

Fig. 4.—AYRSHIRE COW

JERSEY AND GUERNSEY CATTLE

The Channel Islands boast two distinct breeds, which, while differing considerably in outward appearance, agree in the abundance and extraordinary richness of their milk, and the golden yellow colour of the butter. Formerly they were known in this country indiscriminately as Alderneys, but the name is now very properly obsolete. One breed is peculiar to Jersey, and the other to Guernsey, Alderney, Sark, and Herm, and their purity is maintained by local legislation, prohibiting not only the importation of cattle from abroad, but also the introduction of Guernseys into Jersey, and of Jerseys into the other islands.

The **Jerseys**, from their graceful deerlike form, are familiar and attractive objects in gentlemen's parks, their silky hair is usually of a fawn or silver grey, their skin yellowish and almost orange in the tail, their muzzles black, encircled, as are also their eyes, by a zone approaching white, and the horns small, crumpled and yellow with black tips. Of late years, however, every shade of brown, to the colour of a ripe chestnut, is also met with, and in many of these darker animals the colour shades into nearly black on the forehead and muzzle. They fatten badly, though their flesh is good in appearance and flavour. The richness of their milk is such that though less in quantity than that of the Guernseys, the yield of butter by each cow is equal if not greater. The delicacy of their constitution, necessitating their being housed through half the year, renders them peculiarly prone to tuberculosis, and precludes their general use for dairy purposes, though they are unrivalled, save by the Kerrys, for butter making. (Fig. 12, p. 25.)

The **Guernseys** are larger, coarser, indeed somewhat ungainly animals, mostly of a yellow-brown colour, patched with white.* As milkers they are absolutely unrivalled, and

* They are also, however, of red or black and white, but the most prized strain is the "Cloth of Gold," bred by the late Rev. Joshua Watson, which is of a uniform orange buff colour.

from this very fact are often so thin as to be unsightly; but when dry they will put on flesh with startling rapidity, and are thus valuable additions to a general dairy herd, being at the same time less tender and less liable to tuberculosis than the more elegant and smaller Jerseys. (Fig. 13, p. 27.)

Among foreign breeds two only call for notice here, the Dutch, medium-sized black and white animals, yielding large quantities of milk of poor quality, often containing less than three per cent. of fat. This, or a kindred breed, extends under the name of Normandy over north-eastern France. The other breed is the Brittany, the smallest of all, averaging between thirty-two and forty-two inches in height, less even than our Kerrys, to which, in hardiness, activity, and the quantity and quality of milk, as well as in size and colour, it approximates far nearer than to those of the Channel Islands.

CHOICE OF A COW

In selecting stock for a dairy, many and sometimes conflicting interests have to be considered.

If the purpose of the farm be the supply of milk as such to the market, and the disposal of the stock when their best milking days are over to the butcher on the most profitable terms, no breed can equal the Shorthorns "pure" or crossed; and they have accordingly established themselves as the predominant breed throughout the whole or the greater part of the northern, eastern, south-eastern, and east midland counties. If the ultimate utilisation of the carcases be of secondary importance the Ayrshires may be preferable, especially on poor lands, and the average quality of the milk may be raised by a sprinkling of Guernseys, Devons, or polled cattle.

Where there are opportunities for doing a good business in meat, as well as in milk, and the pastures are fairly rich, Devons, Herefords, and polled are to be preferred to Shorthorns, while Ayrshires and Kerrys will be valuable additions

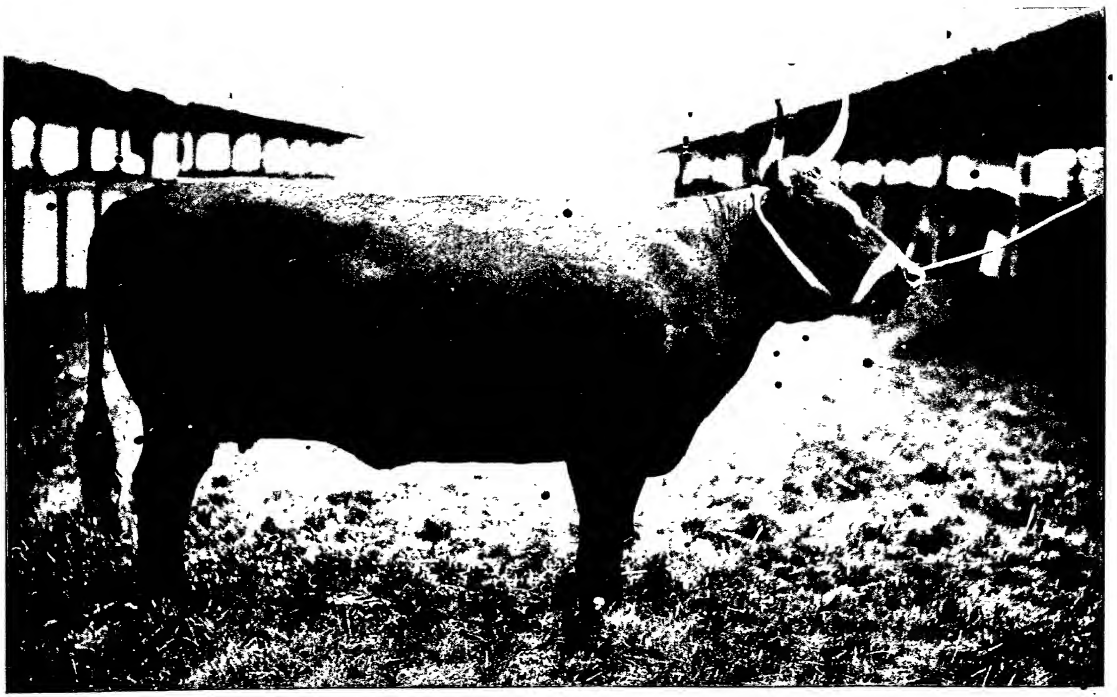


Fig. 5. DEVON

Fig. 6 RED POLLED OR SUFFOLK

in every way; and, lastly, where, as in private establishments and "creameries" or butter factories, richness is everything, that is to say, the pounds of fat rather than the gallons of milk obtainable from each animal are the main or sole consideration, Jerseys, Guernseys, Kerrys, and perhaps Brittany cattle, would be the most profitable; the Jerseys being the most ornamental, but the Kerry and Brittany by far the hardiest. From the butcher's point of view, however, the Jersey is almost worthless, but the Kerry second to none, except, perhaps, the Highland, which with the Welsh have no attractions for the dairy farmer save in their own countries; and few farmers, nowadays, would care to experiment with Dutch cows, which might, if present in any considerable numbers, bring down the mixed milk of the herd below the standard of the public analyst.

The climate, in which elevation of site, aspect, the prevailing winds, the perviousness of the soil, and the amount of the rainfall, are the chief factors, and the nature of the available pasture and food must be assigned a prominent place in the choice of the breeds best adapted for the particular purpose and locality.

The following figures, although from having been taken at the Royal Agricultural Society's shows they are higher than the averages commonly met with, will be useful in showing what can be achieved and should be aimed at with cows of different breeds:

Means of	Total Milk Daily in lbs.	Total Solids per Cent	Fat per Cent
150 Shorthorns	43 13	12.88	3 74
11 Ayrshires	34.26	13.43	4.15
63 Guernseys	28.93	14.10	4.82
158 Jerseys	28.01	14 51	4.80

Two special Jerseys yielded a milk with percentage of (1) total solids 19.25, fat 9.5, and (2) total solids 17.0, and fat 8.5, or 1 lb of butter from 10.5 and 11 7 lbs of milk respectively.

It will be seen from the above that though the weight of milk given by a Shorthorn was to that given by a Jersey or Guernsey as 3 : 2, the weight of butter was only as 16 : 13 or 14; so that while the former are the more profitable for the milk seller, the latter lighten the labour of the creamery and buttery considerably. It must not be forgotten that the food consumed by a cow in the ordinary physiological work is proportioned to the bulk of its body, and that consequently the smaller the animal the more profitable if the yield of milk or of butter, as the case may be, is not very different. From this point of view none can approach the Kerry.

BREEDING

Some persons are in the habit of buying all or most of their milch cows in the open market, and of disposing of their calves in like manner; but most farmers rear the bulk of their stock, and so only can any methodical plan for its improvement be carried out.

It is usual to speak of "pure bred" animals, but the term must not be understood as signifying unmixed descent from time immemorial.

Bulls and cows of the now recognised strains will produce a progeny as identical with themselves as if the breed constituted a distinct species; but with a few exceptions, as the Highland and Welsh, modern breeds have been evolved by selection, sometimes natural, but mostly artificial, within the last two, or at most three, centuries. Complex, however, as may be their origin, they are not mongrels but the result of cross-breeding carried out through successive generations on strictly scientific principles, with the well-defined and intelligent purpose of transmitting to the issue those qualities that were essentially good, or under the circumstances advantageous, and of minimising or ultimately eliminating such as were bad, so as to bring about the survival of the fittest—*i.e.*, those exhibiting in the highest degree all the excellences of

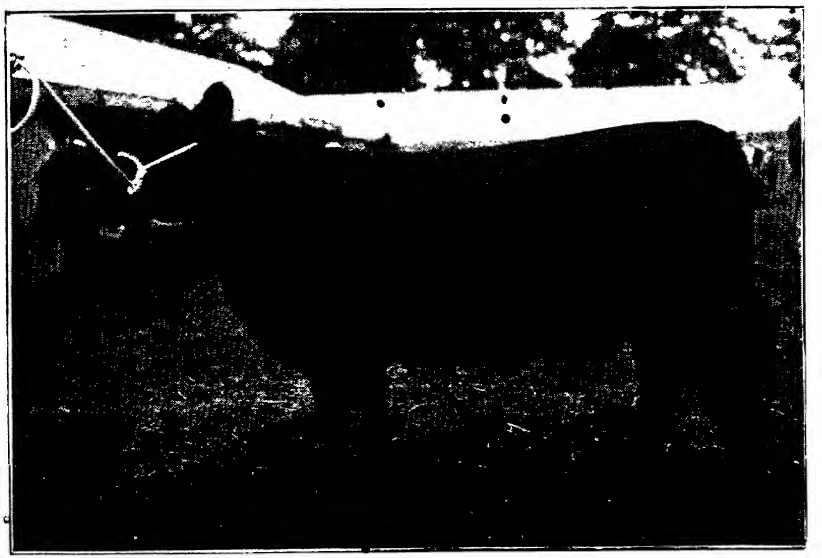
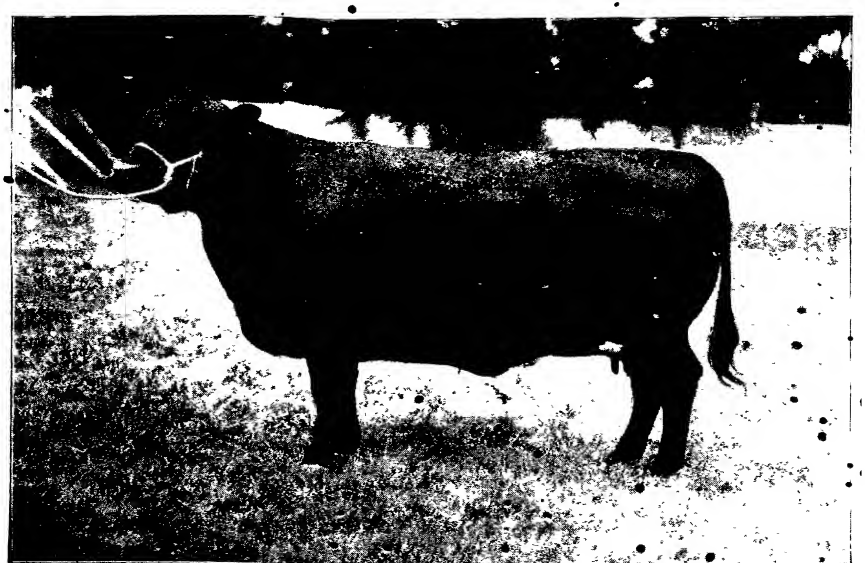


Fig. 7. Galloway Cow.



the race in which the faults have been reduced to the minimum and which are described as "pure bred."

In choosing a bull of bulls questions of cost or convenience must be rigidly subordinated to those of the probable character of the issue. Indiscriminate mating will tend to the production of a race of mongrels exhibiting, it may be, all the vices and few of the virtues of their parents on either side; but judicious crossing may have the very opposite results, while "in and in" breeding, though preserving the purity of the strain, may, especially if the number of individuals be small and too "near of kin," tend to its enfeeblement and ultimate extinction, a fate that seems likely to befall the wild white cattle of Chillingham. When the stock of cows is homogeneous a single bull will suffice, but if the cows be of several distinct breeds more than one will generally be required.

One point, however, must never be forgotten—the extraordinary prepotency of the bull, who will not only impress on his progeny the stamp of his frame and constitution, but also, strange as it may seem, the milk-giving powers (or the reverse) of his female relatives. Hence the importance generally and justly attached to pedigree, including under that term the characters and aptitudes of the collateral relatives. Indeed, the result of crossing even a very ordinary cow with a bull of faultless family history, though himself not of the highest type of physical development, may be more satisfactory than if the bull, though a heavier and finer-looking animal, had come of a stock less remarkable as milkers. In the absence of evidence on this point the degree of development of the rudimentary udders of the bull himself may be taken as a rough indication of the milking capacity of the strain.

Prepotency is naturally more marked the greater the purity of the strain, thus by the constant use of bulls of one breed and of high pedigree a mongrel herd may in two or three generations be entirely transmuted into one of the same

breed as the sires, and all other characters be apparently obliterated; but should one of them be subsequently employed as a bull, there is no doubt that the lost features would be revived, if not intensified.

That there should be a correspondence in size and age between the bull and cow is evident. A bull may be used with moderation as early as eighteen months, and thence on till six years, or perhaps more. To kill them, as some do, at three years, before their true value can have been tested, is a mistake.

CHARACTERS OF A GOOD DAIRY COW

It is not enough to decide on the particular breed or breeds of which the herd shall be composed, since good and bad individuals may be found in all, but judgment must be exercised in the choice of the individual cows. Apart from, and to some extent modifying and modified by the general characters of the breed, are certain features more or less surely indicating the milk-giving capacity of the particular animal. The thighs of the best milkers are rather thin, giving ample room for the expansion of a deep broad udder, which should when filled stand well forwards; the teats should be of medium size, neither long and flaccid, nor, as in some breeds, short and stumpy, and the skin of the udder and teats should be soft and elastic. M. Guénon some years ago called attention to a phenomenon, which, though inexplicable and based on purely empirical evidence, has been accepted by most practical men as a characteristic of a good and trustworthy milker. It is that the duration of each period of lactation, as well as of that during which a cow will continue to be profitable for dairy purposes, and to a less extent the average yield at any time, are in fairly direct proportion to the extent of her "escutcheon," *i.e.*, the surface of the mammary region, perineum and buttocks, over which the hairs that elsewhere are directed downwards are turned upwards, so that the line of junction between these and the others is marked by a sort of frill.

Fig 9 KERRY

Good milkers are to be found in every breed, and so, too, are poor ones. General impressions, or conclusions drawn from the observation of any particular cow for short periods of days or weeks, are not to be relied on. It is evident that the profit to be made out of a herd depends on the average and total yield during the whole period of lactation, and the shortness of the intervals in which the cows are dry. Such knowledge can be acquired only by keeping a "milk register," that is, a book in which the yield of each individual cow is entered separately and continuously. The value of a register is greater the more frequent the observations, a daily record being more accurate than one in which the observations are made weekly. The amount may be entered by measure or by weight, *i.e.*, in gallons or in lbs., the latter being the easier and the more convenient, especially when the fat is estimated in the laboratory; it renders the calculation of the butter-yielding capacity of each cow a simple matter, an important consideration when, as in the Danish co-operative butter factories, the milk furnished by each farmer in the Association is paid for on the amount of fat in his contribution to the common stock. At the same time, the volume can be calculated from the weight with sufficient approximation to the truth for ordinary dairy purposes by merely putting a decimal point before the last figure of the lbs., or, with greater accuracy, by multiplying by $\frac{100}{103}$, *i.e.*, adding two ciphers and dividing by 103. A gallon of water weighs 10 lbs., so 25 lbs. equals 2.5 gallons, but the specific gravity of milk being 1030, a gallon weighs 10.3 lbs., and 25 lbs. $= 2500 \div 103 = 2.427$ gallons, or 2 gallons and $3\frac{4}{16}$ (or $3\frac{1}{2}$) pints. The Dairy Supply Association provides a cheap and portable apparatus or meter, showing at a glance the weight in lbs. and the measure in gallons and pints, no deduction being required for the weight of the pail. (Fig. 11, p. 22.)

But the register is of great value to the dairy farmer who merely sends his milk to the market, or contracts with a dairy company, in guiding him in his efforts to improve his

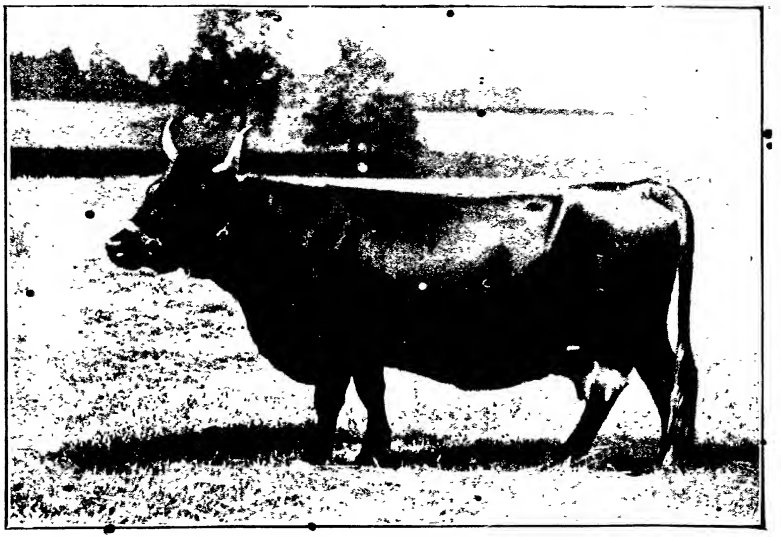


Fig 10. Dexter Kerry

herd by a process of selection, elimination and mating with the most suitable bulls. This last subject, however, is a matter of experience and judgment, which cannot be learnt from books only.

With the comparatively wide range in percentage of solids and of the fat in the milk of different cows, it follows that

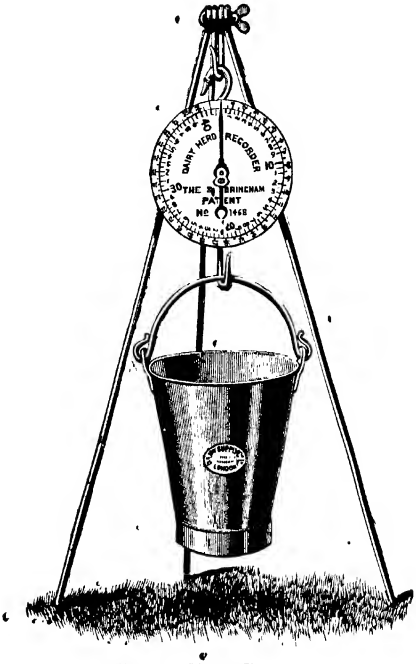


Fig. 11. Milk Recorder

the quantity of the milk, whether estimated by measure or by weight, given by a particular breed or by an individual animal, does not always furnish evidence of its real value. But since their milks will fetch the same price in the market, a cow yielding 3 gallons daily is more profitable to the milk vendor than another giving 2½ gallons only, although of such

richness that it would bear diluting up to the measure of the other, without being rendered inferior. Farmers accordingly speak of particular cows as being good "milkers" or "butter cows," or both, these being represented, for example, by Shorthorns, Jerseys, and Kerrys or Guernseys respectively; though it must not be forgotten that a larger body requiring more food, the three gallons from the one may cost the owner more per gallon than the 2½ from the other. The range is greater than is commonly supposed by those who, being neither breeders nor exhibitors, do not take the trouble to note the yield of each cow. Thus at the Dairy Show held at the Agricultural Hall, Islington, in 1902, the weights recorded daily ran from 8 to 75 lbs.; the figures not exceeding 12 lbs. or so were of course those of very young cows, and the only cow giving over 70 lbs. was a heavy Shorthorn exhibited by Mr. G. Long. Taking the higher figures representing good and easily attainable averages, rather than extraordinary and exceptional individual instances, at the show of that year, we found Shorthorns yielding 40 50 lbs. daily; half a dozen red-polled cattle exhibited by Lord Rothschild, 40–50 lbs; four Ayrshires, 25–30 lbs., two Guernseys, 25–35 lbs., Dexter Kerrys, 20–40 lbs., and Jerseys, 25–30 lbs. The Shorthorns and Jerseys were present in overwhelming numbers, the other breeds were represented by from two to six individuals, Devons, Herefords, Scottish (except the Ayrshire) and Welsh cattle being unrepresented. One of the Shorthorns, a huge animal belonging to Lord Rothschild, gave 58–60 lbs. Considering the relative size and, consequently, the cost of feeding, the Dexters with 20 40 lbs. must be allowed to take the highest place whether for milk or butter-making.

Age at which to put the cow to the bull, and the best season for calving.—It would be well if the young cow were not put to the bull until she was near two years old, though it is usual with common cross-bred cattle to do so at eighteen months, and some farmers, especially in the

northern counties, do this as early as twelve months, although this is bad practice, since the cow, the calf, or both must suffer. The best time is between the beginning of May and the end of July, so that the cow may calve between January and April, but older cows may be made to calve any time before Christmas. The period of gestation is usually from 282 to 285 days, according as the calf is a cow or a bull; and since a cow should be allowed to run dry for six or eight weeks prior to the expected date of calving, it is well to put them to the bull at different times, so that the supply of milk may not be seriously diminished by having too many cows dry at one time. The farmer must watch for the symptoms of "heat," which last but a few days, and do not return until after about three weeks. Conception will, as a rule, take place at this period; but should it not, one must wait for the next appearance of the "heat." The rest from lactation should on no account be less than a month, but need not be more than two, the interval which, as the rule, should be allowed. If this fall in the spring or summer, the cow should be put out to grass, but if in winter, she should be fed with the best hay, some roots, and boiled bran and meal.

Abortion and "slipping" of the calf.—The causes of abortion are not well understood, and the habit is often acquired; anything tending to fatigue or excitement conduces to it, and it seems to be sometimes epidemic. There is strong evidence in favour of the belief, though it is denied by some high authorities, that ergotised grasses, most frequently met with in damp swampy pastures, are a cause of abortion, while a hereditary tendency is occasionally observed.

When the time for parturition approaches the cow should be brought to the homestead and kept apart from others in a quiet place, where she may be constantly under observation, and have bran mashes or laxatives, and about 2 lbs. of oil cake in place of a portion of dry fodder. The act of *parturition* does not occupy more than half or three quarters of an

Fig. 12. JERSEY COW

hour under normal conditions, during which time the cow should be watched and assistance rendered if necessary, otherwise she is best left to herself. If, however, the presentation is unnatural, if any obstacle exist to the expulsion of the fœtus, or there be abnormal delay in the separation of the placental structures, the help of a veterinary surgeon, or at least of an intelligent and experienced man, should be had recourse to, for the misdirected efforts of an ignorant or unskilled one may lead to the loss of both cow and calf. After calving is over she should have a warm mash, and her water should be slightly warmed, an aperient of 1 lb. of Epsom salts and ½ oz. of ginger in warm water is generally advisable, but spirits, &c., are not wanted. Next day if fine she may be taken out for a few hours, but for three or four more days at least she should be housed at night. It is usual to take the calf away at once, but if it be left with its mother they must both be kept quiet. Young heifers fare best if allowed to suckle their first calf for some weeks, since the udders are thus rendered flexible and fit for milking better than by artificial means. For a few days it will be necessary, if the calf have been taken away, to draw off the milk three or four times a day, to prevent over distension of the udder with perhaps inflammation and abscess. If, however, the calf be left with its dam, there is no need for milking, provided the cow does not drive the calf away, which she is apt to do if the udders be hard and painful. On no account should a cow be put to the bull within six weeks of calving, even though she may be in heat; for involution of the uterus not being complete she will either not conceive, or, if she do, will be very liable to abort. If a cow has aborted previously, or has dropped a calf prematurely, she should be allowed three or four months' sexual rest, that the uterus may have time to return to its normal and healthier condition before being again excited to functional activity.

Feeding and weaning of calves.—Mother's milk is the natural and only perfect food for the young of all mammalian

Fig. 13. GUERNSEY

animals; and since the milk secreted in the first few days following parturition, the colostrum or "beastings," is quite unfit for the market, but, provides a natural aperient, specially adapted to the calf, there is no excuse for taking it from its dam for the first week. Again, the young of the lower animals are able to feed themselves at a much earlier age than the human infant, so that, although left to themselves they would not wholly abandon their mothers for several months, there is little difficulty in weaning them.

But the wish to make the most of the milk for dairy purposes or the market offers a strong inducement to farmers to attempt the rearing of the calves from the first, or from the earliest possible period, on artificial foods, either added to skim milk, the butter being sold, or even without the addition of any milk whatever. This practice is not to be recommended, for none of these foods can really take the place of milk, and the health of the calf will inevitably suffer, with remote effects on her future development. But since the daily yield of well-bred cows is greater than the requirements of the calf, for which during the first month about three quarts are sufficient, one of two courses may be followed after the first week, during which the milk cannot be used for dairy purposes, and the cow should be allowed to suckle her own calf. Either two calves may be allowed to one cow, until they can be weaned, when two more born subsequently may be put in their places; or the calf, being taken from the cow after the first week, may be fed from a pail with a sufficient quantity of milk for several weeks longer, and then with a mixture of milk and artificial food until it is able to take grass and other fodder. In the northern counties the usual practice is to leave the calf with its mother for ten days or a fortnight, then for another fortnight it is fed on new milk from a pail, next on new and skim milk mixed, and after a month on skim milk to which meal or crushed linseed is added in quantities adapted to the growth of the animal, until it is gradually weaned to

chopped hay, and roots, and later to crushed oats and linseed cake.

In Ayrshire calves intended for dairy cows are reared on pure milk only for four to six weeks, the quantity being gradually increased from three to four and five quarts daily, when meal, crushed linseed, &c., are added, and the milk is wholly withdrawn after the eighth or tenth week.

The rearing of calves without milk should never be attempted, being foolish and short-sighted, for the injury to the health and future value of the animal, especially for dairy purposes, outweighs by far any profit derived from the sale of the milk, nor can skim milk take the place of pure milk, since the fat is essential to the nutrition of the calf. When however, it has reached the age of six weeks or thereabouts and its digestive powers are stronger than they were in the first month, skim milk may be given, provided the deficiency of butter fat is made good by the addition of some other and cheaper fat, as that of linseed meal or finely crushed cake. For directions for making and mixing different mashes, gruels and other food during the process of weaning, such works as "Youatt's Complete Grazier," by Dr. Fream, or Prof. Sheldon's "Dairy Farming" may be consulted.

CHAPTER II

THE HOUSING OF COWS

Cow-sheds, Cow-houses, Shippons, or Byres.—The question of the housing or sheltering of cows in this temperate but uncertain climate has to be considered from several points of view. The well-known freedom from tuberculosis of the hardy cattle roaming at large on the moors and mountains of Scotland, the Steppes of Russia, and the prairies of America, testifies to the healthiness of a life in the open air, especially where cliffs, rocks, or trees afford some shelter against storm and rain. But it is only in very mild and sheltered localities that even the hardier breeds of dairy cows can stand exposure all the year round, and then only at the cost of their yield of milk, as well as of a considerable addition to their food, much of which goes to the maintenance of the body temperature instead of being utilised for milk production. On the other hand, the experience of many of the Dutch dairy farmers shows that cows, if kept in clean, dry, and well-ventilated sheds, may be maintained in good condition for years; but the prevalence of tuberculosis among Jerseys and other high-bred tender animals, that are necessarily sheltered or housed during eight months in the year, is equally conclusive as to the danger of infection, inseparable from overcrowding in buildings unprovided with the means of really efficient ventilation. We may therefore conclude that some shelter must be provided for from four to eight months in the year, according to the climate, the weather and the character of the herd; but that the longer the cows can remain out without detriment or suffering, that

is so long as they enjoy the open air life, the better. Even in the meadow, however, some kind of shelter is desirable, if not necessary, to afford protection against cold winds and rains. It need not be even an open shed, although that is the best; a high fence will keep off the wind, and trees under the spreading boughs of which they can stand will serve as shelter from heavy rains, or from the excessive heat of the sun.

It is an excellent practice in very hot weather to keep the cows during the heat of the day in airy sheds, where they are protected from the sun's rays and the attacks of flies, turning them into the meadow after the evening's milking to enjoy the cool air at night.

In the so-called "model dairies" or show establishments, the cow-sheds leave nothing to be desired, and at many country houses little less attention is bestowed on them than on the stables; but in the ordinary class of dairy farms and in such cow-yards in towns as are not run by way of advertisement, the sanitary conditions are as a rule abominable. Rough walls scarcely admitting of lime-washing; thatched roofs harbouring vermin and infection, or tiles cold in winter and hot in summer; floors pitched with large cobble-stones, the spaces between which afford lodgment for dung which cannot be swept or washed out; with no regular fall to carry off the surface drainage, urine and washings, and no provision for securing ventilation, or for warming a draughty building, save the body heat of the animals, whose legs, hind-quarters, and perhaps their very udders are besmeared with dung. Without will be found a "straw-yard," where a huge mass of litter and dung rests on an uneven and more or less pervious bottom of rough broken stones, puddle, or a make-believe of concrete, from which in dry weather ammoniacal exhalations rise polluting the air and impoverishing the manure, and which after rain is as sodden as a sponge with so much of the soakage as does not slowly run off by a drain to foul the water of a neighbouring pond or ditch, euphemistically

called a brook, from which the cows, and possibly the cottager some way off, obtain their drinking supply.

In towns the straw-yard and pond are absent; but while the water is drawn from the public mains, or to save expense from a shallow well sunk in the foul soil, the place of the straw-yard is taken by a dung-pit, the contents of which, from the more sparing use of litter, are of a semi-fluid consistence, and their removal from time to time is attended by a sickening stench.

That under such conditions the cows can maintain perfect health is incredible, and milk drawn and exposed while still warm to such an atmosphere, for even a few minutes, cannot fail to absorb the odours and to be contaminated by the filth, or in dry weather by dust, the vehicles of bacilli which tend to render it prone to speedy souring and decomposition.

In Holland and in Norway, indeed, the cows are mostly stall fed, but the most scrupulous attention is paid to the cleanliness of the animals and of their surrounding, the cows are groomed or "curried" daily like horses, the stalls are kept dry and clean, the supply of fodder is ample and nourishing, and pure water only is given, with the result that notwithstanding their continuous confinement they are always in good condition.

The shelters for cows in England are of two kinds, (1) open sheds, and (2) closed houses, an intermediate form of shelter being the open shed, the front of which can be closed in cold, and, especially in cold and wet weather, by movable shutters either reaching to the roof, or leaving a space above for ventilation, an arrangement much in favour in the Scottish Lowlands.

Open sheds around a yard do very well for the hardier breeds of cattle, in places not exposed to cold winds; but in high, bleak, or cold and damp localities, and for Jerseys everywhere, closed sheds or cow-houses are indispensable. These sheds may be single or double; in the former (Fig. 14), a single row of cows stand with their heads to the back or higher

wall, a walk intervening between their tails and the front or lower wall, with a lean-to roof. In the latter, which have a ridge roof between walls of equal height, two rows of cows

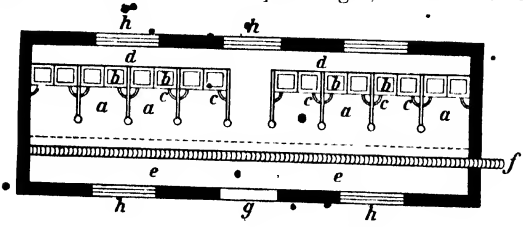


Fig. 14. Plan of Cow-House

a, *a*, stalls for two cows; *b*, *b*, fodder troughs; *c*, *c*, drinking troughs; *d*, feeding walk; *e*, dung walk; *f*, gutter draining to tank; *g*, door; *h*, *h*, windows.

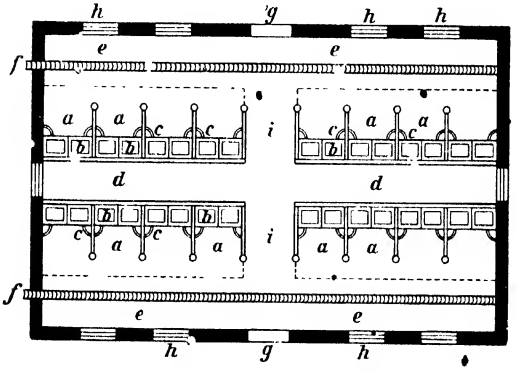


Fig. 15. Plan of Cow-House

a, *a*, stalls for two cows; *b*, *b*, fodder troughs; *c*, *c*, drinking troughs; *d*, feeding walk; *e*, dung walk; *f*, gutter draining to tank; *g*, door; *h*, *h*, windows; *i*, middle gangway.

stand head to head, or, better, tail to tail. In the first case (Fig. 15), there is a narrow walk between their heads, giving access to the feeding-troughs on either side, and a gutter and broad walk between their tails and either wall; in the

second (Fig. 16), there is a single broad passage, with a gutter running down the middle of the shed, and a feeding walk on each side between their heads and the wall. In this arrangement as in the single shed, the feeding

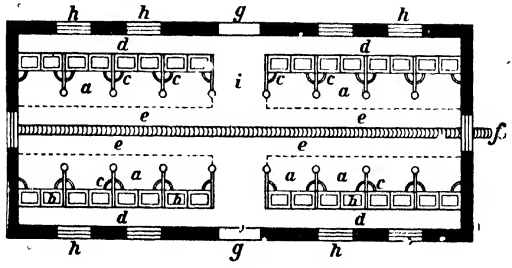


Fig. 16 PLAN OF COW-HOUSE

a, *a*, stalls for two cows; *b*, *b*, fodder troughs; *c*, *c*, drinking troughs, *d*, feeding walk; *e*, dung walk; *f*, gutter draining to tank, *g*, door; *h*, *h*, windows, *i*, middle gangway.

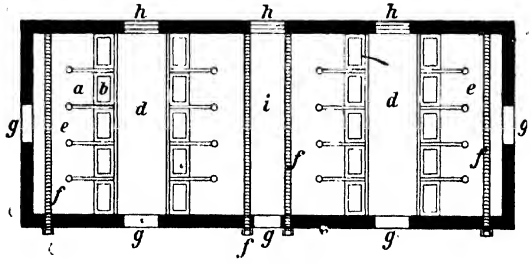


Fig. 17. PLAN OF COW-HOUSE

a, stalls for two cows: *b*, fodder troughs: *d*, feeding walk: *e*, dung walk, *f*, gutter draining to tank: *g*, door, *h*, *h*, windows; *i*, middle gangway; drinking troughs as before.

walk is often dispensed with, the troughs being close to the walls; but there are two objections to this, first the cold draught along the wall, and secondly, that the wall, being bespattered with the nasal mucus of such cows as

chance to suffer from cough or catarrhs, may, if any one be suffering from tuberculosis or other infectious lung disease, be the means of infecting previously healthy animals subsequently occupying the same stall, or those adjoining it, while it is very difficult to replenish the feeding-troughs in the presence of the cows.

The *ventilation of single sheds* is effected by apertures for the admission of fresh air in the front or lower wall about five feet above the ground, with outlets at the summit of the roof: in the double shed the inlets are in the walls on either side, and the outlets in the ridge of the roof. From this point of view, the head to head position of the cows is preferable, since in the tail to tail arrangement the heads of the animals are exposed to the cold currents of the entering air, unless the apertures of inlet are fixed at a considerable height, when the ventilation is less efficient.

The *inlets* should be louvred to break the draughts, and the outlets in the form of a ridge ventilator, or as it is called in Germany, a riding roof, extending the whole length of the building, or of turrets, as Boyle's or Musgrave's one to every two or three cows, either plan preventing the descent of snow or rain, or the tendency under certain circumstances to reversal of the current of cold air on to the heads of the animals. Besides the louvred inlets, which will be open at all times, provision should be made for supplementary ventilation of a freer kind, technically called "perflation," for completely and rapidly changing the air of the building when the cows are out, and for keeping it fresh and cool when the shed is occupied in warm weather, just as the windows of a dwelling-room are opened wide, or those of a school in the intervals of play. For this purpose large openings the size of ordinary domestic windows, closed by shutters moving on hinges above or at the sides, should be provided, two or more in each of the opposite walls, in addition to the permanent louvres and the doors.

The question of *wall surfaces* is a difficult one; in model or

show dairies, and in those attached to gentlemen's houses, where every expenditure need not be considered, nothing is equal to white glazed tiles, into which one square of slate may be let opposite each cow, for noting her yield, &c. In other cases the walls may be faced with the smoothest cement obtainable, for rough walls are always objectionable. If they must be of bare brick they should be frequently lime-washed during the time the sheds are in use.

The *roofs*, of slate or tiles, not thatch or rough stone slabs, may be boarded to secure uniformity of temperature, but should not be ceiled, as, save under special arrangements, this would interfere with the exit of foul air through the ridge outlets.

The paving of the stalls and gangways should be of hard "pavior" bricks, or of concrete, which is preferable as giving a more uniform surface, and adapting itself more readily to the several gradients required for carrying off the wet. But the concrete must not be too smooth to afford a foothold to the cows. It may, while still soft, be impressed by means of a roller with small squares or other pattern, as is done on "granolithic" paving. It should slant gently towards the gutters, which should be formed of glazed half-pipes bedded in the concrete, or be moulded in the concrete itself, and faced with cement to the smoothest surface possible. Circular pipes with a longitudinal slot are objectionable, as being liable to become choked, when they are cleared with difficulty. The gutter, which must have a good fall, should be carried without a trap to a brick tank, cement lined, covered in and provided with a pump. Beyond each row of stalls the gutters may be made to discharge into a drain with manholes, &c., especially when the number of cows is large, or the buildings are near the dairy or the dwelling. The liquid, consisting of urine and dung dissolved in the water with which the floors of the sheds have been washed down, constitutes a highly concentrated liquid manure, which may be applied by means of a water-cart to grass land, or mixed

with dry earth and used as a top dressing. It may be used freely on garden ground, but before applying it to growing grass in dry weather it is advisable to dilute it further, lest it should "burn" the herbage. To discharge it into ponds or watercourses is wasteful and insanitary, and to allow it to run into the straw-yard is scarcely less so.

Every day when the cows are taken out for exercise and airing, as they ought always to be, the floor of the sheds should be washed down with a hose, and the dung and washings swept into and along the gutters.

With the old rough cobble pitching on which the cows could not lie with comfort, a good supply of litter was necessary, but with brick or concrete paving this can be dispensed with, except a little under their forefeet on which to kneel when lying down, and for this purpose moss litter, or where it is cheap, sawdust, may be substituted for straw, which is expensive, and, except on very heavy lands, does not enhance the value of the manure. Under former conditions it was necessary as a sponge to absorb the semi-fluid dung of cows, but is not required if this be converted into liquid manure, when the straw-yard itself may be abolished with advantage. In the sheds the cows may be tied up without any partitions between them, or they may be arranged singly or in pairs in stalls; in the latter case, with a small partition between them at the manger, that each may have her separate allowance of food. The partitions and mangers are commonly of wood, but cast-iron fittings are neater and cleaner, and present manifest advantages in the ease with which they may be disinfected in the event of any of the cows being affected with foot and mouth disease, or tuberculosis. Each cow should have a separate water trough supplied by pipes from a cistern at a sufficient elevation, and frequently cleaned. The importance of clean water is not appreciated as it should be; water-troughs in the yard should be kept clean, and fixed at such a height above the ground that while the cow can drink from them easily they shall be

unable to foul the water with their urine or dung. It cannot be denied that cows will willingly drink, indeed often seem to prefer, polluted water, but the effect on their milk if not on their general health must be bad. The explanation is undoubtedly to be found in an instinctive craving for salt which the urine supplies, but which would be better given as such with the food.

In the plans here shown separate feeding and drinking troughs are provided for each cow, but in urban dairies and places where a public and abundant water service is available, it is becoming usual to have a single trough of glazed half drain pipes, one foot diameter, running the entire length of the shed, with a smooth rounded kerb, not rising more than fifteen inches from the ground, so that the cows may eat and drink while lying down or standing. It is used alternately as a feeding and a drinking trough; when they have done eating the remains of the food are swept out, and the water is turned on, first washing the trough out, and then filling it with clean water for drinking; the retention of sour meal or rotten green food is thus avoided, as well as the fouling of the water; and the cows seem to enjoy leisurely lapping from the comparatively shallow channel better than taking heavy draughts from a pail. It is, however, open to one objection, viz., the possible spread of infection from the nasal discharges and expectoration of diseased animals.

Cubic space.—There are unfortunately no statutory requirements as to the minimum number of cubic feet to be allowed for each animal in cowsheds, as there are in the orders of the Privy Council and Local Government Board in the case of barracks, workhouses, lodging-houses, factories, and schools; and this defect or omission reduces the demands of the Dairies' and Cowsheds' Orders for proper space and ventilation to the character of a pious wish, which each may interpret as he thinks fit. The bylaws of some local authorities, mostly County Councils, have in some instances attempted to supply the deficiency, but too often their requirements, being mere

guesses and not based on any scientific data, are of no practical value whatever, and the 600 cubic feet that satisfies some, would, after allowing for roof space, walks, &c., leave little more than the actual standing room; while other authorities insist, ostensibly at least, on 1000 cubic feet or more. The fact is that the volume of air required, and of carbon dioxide given off having been ascertained, and a standard of purity compatible with health determined, the cubic space required is that which permits of the maintenance of the standard of purity without necessitating such frequent changes of the air that its movements shall be unpleasantly felt in the form of cold draughts. Thus, to maintain the air of a room occupied by men or women at rest, each giving off 0.6 cubic feet of CO_2 per hour, free from perceptible smell or closeness, that is containing no more than 0.2 part per 1000 of respiratory or organic CO_2, a supply per head of 3000 cubic feet of fresh air per hour is necessary; and since the air of the room cannot in cold weather be renewed oftener than three times in the hour without producing unpleasant draughts, each person must have at least 1000 cubic feet of space. Larger animals as horses and cows, require a supply of 10,000 to 15,000 cubic feet per hour, and this would, if draughts are to be avoided, mean 3000 to 5000 cubic feet of air space. This may not be practicable under actual conditions, but 1500 is not an excessive demand, and would be met by such measurements as, for example, the following: mean height of roof 15 feet, width of feeding walk 2 feet, of feeding trough 2 feet, of gutter and slanting sides 2 feet, and of raised main pathway 3 feet, and for each stall a space of 7 feet in length by 6 in width, and 3 inches for thickness of partition. The result of raising the height of the shed while reducing the width of the stalls would not be the same on the health of the cows, though arithmetically identical. Even in the open air troops on the march feel a great difference between open and close order, and the effect of close juxtaposition of bodies in a

closed building is worse. The dimensions here given may be taken as a fair average, but may be varied according to circumstances.

In a shed completely open through its whole length, 1000 cubic feet might suffice, and 1200 if one only partly closed, whereas in a soundly built cow-house, in which in cold weather the doors and "window shutters" are closed, the louvred ventilators alone remaining open, and the cows, Jerseys, for example, shut in for great part, if not all, of the day, 2000 cubic feet, exclusive of any roof space higher than 15 feet from the ground, would be none too much.

"*Fodder bins*" between the rows of stalls and lofts for storage of hay, &c., over the sheds are objectionable, the fodder being in either case exposed to the exhalations from the manure and bodies of the animals, while lofts interfere with the ventilation.

The relations between temperature, food consumed and milk yielded are well known, though not capable of so precise estimation as that between the consumption of fuel and available power of a steam-engine. Food is utilised by all warm-blooded animals for the repair and growth of their tissues, the maintenance of the body heat and the exercise of bodily functions; and in the case before us, the production of milk. Exposure to a low temperature involves an increased consumption of food, or a fall in the yield of milk, or both; and the warmer the sheds the greater, *ceteris paribus*, will be the secretion of milk. But if, as is necessarily the case in buildings not provided with any means for artificial warming, this heat be that derived from the bodies of the animals themselves, and prevented from escaping by the restrictions put on the ventilation, the air must be polluted with the products of respiration and cutaneous exhalations, and the cows condemned to breathe it become enervated, prone to catarrh, and if, as is almost inevitable, one infected animal be introduced, sooner or later fall victims to tuberculosis. It is thus that in this country Jersey cows are supposed to be

specially liable to tuberculosis, as in every country are those compelled to pass the greater part of their time in confinement.

Attempts have been made on a small scale and in some "model dairies" to warm the sheds by artificial means, though hitherto without success, the expenses reducing too far the already narrow margin of profit; but with the great improvements made of late years, especially in Germany, in the art of central heating, in which by the warming of the incoming air ventilation is effected without draughts and heating without closeness, there are reasonable grounds for believing that, at any rate in large establishments where steam-power is in constant use for other purposes, where higher profits are obtained by butter- and cheese-making than could be on the sale of the milk alone, and where fuel could be had at a moderate cost, these difficulties might be overcome; and it should not be forgotten that the increased yield of milk, without the increase in the allowance of food for maintaining the temperature of the animals' bodies, as well as the improvement in their health and the lessened liability to tuberculosis consequent on the liberal supply of fresh air, together with warmth, would be no small set off to the cost of the installation and working expenses.

COVERED YARDS

The experiment of covered yards has been tried in several places, chiefly in the northern counties, in the case of both dairy cows and of stock fattening for the market. It would be specially suited to Jerseys and such less hardy breeds, combining shelter from cold and from rain and snow, which exert a far more depressing effect on the body temperature, and consequently on the yield of milk, than any degree of dry cold, with facilities for ventilation scarcely to be obtained in the cow-house itself, besides presenting other economic advantages.

The best angle for the slant of the roof is one of 40° with

the horizontal, and the spans should not be too great, since the greater the length of roof from ridge to bottom the more

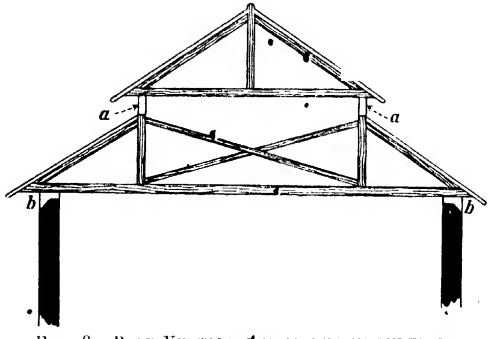


Fig. 18. Roof Ventilation as recommended by Sir H. M. Thompson

At the unshaded portion of the queen posts at *a*, *a*, the spaces between the posts are open for ventilation, and at *b*, *b*, along the top of the wall, apertures are left in the brickwork at intervals, to act as air inlets.

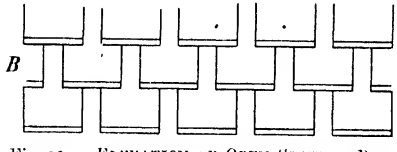


Fig. 19*a*. Elevation of Open Slating Roof

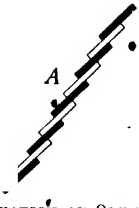


Fig. 19*b*. Elevation of Open Slating Roof

rain finds its way through; a large yard should therefore be covered by two or three spans, with round well-inclined gutters between them. Roof ventilation is preferable to

that by apertures in the walls, which could not be adopted if the yard were surrounded on all four sides by sheds and other buildings. Roof ventilation may be effected in many ways, one being to have apertures under the eaves and a "riding roof" over the ridge of the main roof (Fig. 18). Another is by "open slating" (Figs. 19*a* and 19*b*), in which spaces 2½ inches wide are left between each slate, and inlets provided under the eaves, while a third is presented by the board roof of Mr. Cundy. "It consists of a covering of boards from ½ to 1 inch thick, laid on purlins of 7 inches by 2½ inches, from 4½ to 5½ feet apart. These rest on principal rafters placed at intervals of from 14 to 16 feet, their scantling depending on the width of span for which they are required. For a span of 30 feet, 9 inches by 3 inches is amply strong enough. For cover well-seasoned white boards are, owing to their greater freedom from knots, considered the best, although red boards would probably be found the more durable. They are used in widths of 7-9 inches, the former being preferable as less liable to warp. Before the boards are laid studs are driven into the purlins at the points where the boards would have come into contact with them, and the boards resting on these studs are securely nailed to the purlins.

"The purpose of the stud is to allow a free downward course to any water that may penetrate the roof, and to prevent its lodgment on the purlins, besides securing a free circulation of air between the boards and the purlins, thus tending to the preservation of both from decay.

"The boards are laid ¼ inch apart, giving light to the yard, and also affording the means of ventilation. Grooves about ½ inch wide and ½ inch from the edge are made in them to catch the rain when blown athwart the face of the roof, before it reaches the openings, and to conduct it down to the eaves spout. A special feature of this roof is that, though the interstices give sufficient light to the yard, and admit air enough for good ventilation, yet the wet that finds its way through them is in quantity extremely small—quite too

insignificant to interfere with the comfort of the animals or to impair the value of the manure." * One cannot, however, but think that the introduction of a certain area of strong sheet-glass into any of these roofs would, by admitting more light, effect a considerable improvement. Corrugated iron has been used for the roofs of covered yards, but it is far inferior to either slates or boards on the score alike of comfort and durability.

There is little if any difference in the efficiency of slate or board roofs ventilated on Sir H. M. Thompson's plan at eaves and ridge, for though the former material is the less perishable, slates are more liable to displacement and call for more frequent repairs, and the prime cost of boards being only half that of slates or tiles, double the area can be covered in for the same outlay. But, all things considered, the "open slate" roof is perhaps the most economical of all.

The advantages of covered yards are (1) economy of food through the protection of the animals from cold and wet, without the injury to their health from confinement in closed sheds throughout the winter; (2) the superior quality of the manure; and (3) saving of litter to the extent of half the quantity required in the ordinary straw-yard, which unfits the manure for direct application to the land until it has lain in the dung heap, with turning again and again, long enough to effect its disintegration. The straw is thus saved for purposes of fodder.

Drinking ponds.—A running stream offers the best source of drinking water for cows when out to grass, but more often a pond is utilised for this purpose. Where such natural ponds are not available an artificial one may be made by excavation in some natural depression and carrying surface drains into it from the higher ground all round. The bottom of such a pond should be made as impervious as possible by puddling clay with gravel or chalk. But whether the pond be natural or artificial it should be kept

* "Youatt's Complete Grazier," by Dr. W. Fream, 14th ed. 1900, p 663.

as clean as is practicable by fencing it all round except at one place where the cows may approach it by an inclined causeway paved with cobbles, clinkers or coarse concrete carried some distance into the pond, and at the end of this a rail should be carried across to prevent the cows from wading into the deeper part and disturbing the mud with their hoofs. From time to time their dung should be removed from the causeway, and duckweed, and such perishable floating vegetation from the surface of the water. Plants of a higher order, fishes, and above all crayfish, the scavengers of all collections of water, tend to maintain its purity.

CHAPTER III

THE FOOD OF THE COW

THE uses of food are twofold: (1) to provide materials for the growth of the young, and the repair of the tissues and elaboration of the body fluids, &c., in the adult; and (2) to serve as fuel for the maintenance of the body heat under varying conditions of external temperature, and the generation of energy, to be expended in such internal work as that of the heart, and externally as muscular exercise. The production of milk and the putting on of flesh and fat fall under the first of these heads.

All foods belong to one or other of three classes: (1) **Albuminoids** or **proteids**, (2) **Fats**, and (3) **Carbohydrates.** All, even the apparently driest, contain water in proportions varying between 5 and 95 per cent., what more is required by the animal economy being taken separately as drink. The first alone contain nitrogen, the second and third consist of carbon, hydrogen and oxygen only, the hydrogen and oxygen in the last being present in the proportions in which they exist in water, that is to say one atom of oxygen to two of hydrogen, or, by weight, eight parts of oxygen to one of hydrogen, together with carbon, whence their name carbohydrates, the fats, in which such proportions are not maintained, being described as hydrocarbons. The carbohydrates include all forms of sugars, gums and starches. Theoretically albuminoids alone would suffice to maintain life, serving for fuel as well as for repair, but in the process of oxidation and metabolism the nitrogen is eliminated as urea, &c., by the kidneys on which an

excess lays an undue strain; while the others, being burnt off into carbonic dioxide and water, furnish the best forms of fuel, the fats being especially valuable when the animal is exposed to great cold or fatigue. Fats are not stored in the tissues as fat, nor do the carbohydrates, as is commonly supposed, produce fat, though they lead indirectly to its deposition. Fat is really formed from albumen, but the carbohydrates, being the most easily oxidised form of fuel, act, when supplied in excess, as what the Germans call *Sparmittel*, *i.e.*, they spare the albumen from being burnt off, and leave so much of it as is not wanted for the repair of the tissues, free to be converted into and stored up as fat, a molecule of albumen being broken up into one of fat and one of urea. This will be evident when one observes the effect of the several kinds of food on the production of milk.

The **maintenance** or **subsistence diet**, that is the minimum required for maintaining the equilibrium without increase or loss of weight of an animal at rest and in an equable and normal temperature, has been determined by some German experiments to be for an ox or cow weighing 1000 lbs. about 0.5 or 0.6 lb. of digestible albumen and 7.1—8.4 of digestible non-nitrogenous food-stuffs. This is the irreducible minimum, and much more is necessary if the animal is exposed to cold, or is giving milk, is pregnant, or is undergoing the process of fattening.

Though the albuminates alone contain nitrogen, the nitrogen in a given article of food cannot be taken as indicative of its richness in albuminous nutriment; for a variable proportion, ranging from 5 to 10 per cent. in cake and cereals to 50 to 60 per cent. in roots, is present in the form of amides analogous to the waste matters or products of the metabolism of albuminoids in the animal organism, and having no dietetic value, while a smaller proportion represents the nitrates, and should therefore be referred to the salts.

Of the true albuminoids too a part escapes digestion,

especially that contained in the bran and husks of seeds; and the carbohydrates in like manner comprise, besides the easily digested starches and sugars, the mature cellulose or lignine of woody fibre which resists the action of the gastro-intestinal secretions. The digestibility of foods must therefore be taken into account no less than their composition, and constitutes the difference between the crude and the decorticated cotton cake and between hay cut so soon as the flowers appear, and that left until the seed is ripening. The proportion of water to dry solids is fairly uniform in each class of foods, dry fodders containing from 10 to 16 per cent. of their total weight, and the green foods from 80 to 90 per cent., potatoes alone among the latter having but 75 per cent., and turnips 92, the driest of all is decorticated cotton cake with 3·2 per cent.

Oil cakes with 20 to 40 per cent. of albuminoids, and 10 to 20 per cent. of fat (except the undecorticated cotton cake, which has but 5 or 6 per cent.), are the richest and most concentrated of all foods. Peas, beans, &c., are rich in albumens but poor in fat, while cereals contain the largest proportion of soluble carbohydrates, 55–70 per cent. of starch, peas and beans having the next largest, 45–50 per cent. The insoluble and indigestible woody fibre constitutes 35–40 per cent. of straw, 26 per cent. of hay, and 20 per cent. of undecorticated cotton cake.

The analyses of **straw hay** and even of **fresh grass** are at the best unsatisfactory, since a large and variable proportion of each group of proximate constituents exists, as we have said, in innutritious forms, the nitrogenous as amides, the carbohydrates as cellulose or woody fibre, and the fats as waxy bodies; the proportions of these, with the exception of the amides, rapidly increasing the longer the mowing is deferred.

Of the salts, collectively described in analyses as "ash," and which are especially required for the formation of bone, oil-cake and bran contain the largest proportion of phosphates,

and hay and straw the least; clover hay, bean straw, and turnips are the richest in lime; potatoes and cereals, especially maize (and rice), the poorest. Potash is present in fair amount in most foods except the cereals, but soda and lime rarely, though the former may be supplied in the form of common salt, and both occur in the water drunk, the hardness of spring and river water being usually due to the presence of calcium carbonate.

The composition of **ripe seeds** as cereals, pulse and those which are crushed into "cake" is very constant, but that of grass and roots varies considerably with the degree of maturity, the soil, and the water supplied. Luxuriant growth is attended by an excess of water and corresponding deficiency of solids, which in very large mangels, for instance, may not exceed 6 per cent., but in smaller and comparatively stunted roots may amount to 15 per cent.; while the proportions of soluble and insoluble carbohydrates, of albuminoid and non-albuminoid nitrogen, &c., vary in like manner.

The following table from Warington shows clearly the change in composition, nutritive value and digestibility of grass from the same pasture, cut on three consecutive days, and well harvested; the first cutting was used green, the others made into hay, but the analyses are strictly comparable, the percentages being those of the dry substances only.

Date of Cutting.	Nitrogenous Substances.	Fat	Soluble Carbohydrates	Woody Fibre	Ash
May 14	17.65	3.19	40.86	22.97	15.33
June 9	11.16	2.74	43.27	34.88	7.95
June 20	8.46	2.71	43 34	38.15	7.34

Among **roots**, potatoes contain the largest, and turnips the least amount of solid matters, but when germinating not only does the starch of potatoes undergo destructive changes, and the nitrogenous matter become converted into amides, but solanine, a body closely allied to atropine, and naturally

present in the fruit, is formed in quantities sufficient to make the roots unwholesome if not actually poisonous.

PERCENTAGE COMPOSITION OF ORDINARY FOODS.

Food	Water	Nitrogenous substances	Albuminoids	Soluble carbohydrates	Woody fibre	Fat.	Ash
Cotton cake	12.2	20 8	19 3	35 6	20.8	5.4	5.2
,, ,, decorticated	8.2	44.0	40 9	21.5	0 0	13.5	6.8
Linseed cake	11;7	27 0	25 4	34.2	9 0	11 4*	6.7
Peas	14.3	22 4	19 7	52 5	0 4	2 0	2 4
Beans	14.5	25 5	22 4	45 9	0 4	1 6	3.1
Oats	13 0	12.0	11.9	55 4	10 0	6.0	2.7
Wheat	12 3	11 7	10 2	70 0	2.4	1.8	1 7
Barley	14 0	10 6	10 0	64 1	7.1	2 0	2 2
Maize	11 0	10 4	9.3	70 0	2.0	5.1	1.5
Malt dust	10 0	23 7	17 3	43 8	13 5	2 2	6 8
Wheat bran	14 0	14 5	11 7	51 3	10 1	4 0	6 1
Brewers' grains	76 6	4 9	4.8	11.0	5 2	1.1	1.2
Clover hay	16.0	12 3	10.2	38 2	26 0	2.2	5.3
Meadow hay	14 3	9 7	8 3	41.0	26 3	2 5	5.2
Bean straw	16.0	6.3	5 7	37.1	35.0	1.0	4.6
Oat straw	14.3	4 0	3.8	36.2	39.5	2.0	4.0
Barley straw	14 3	3.5	3.2	36 7	40 0	1 4	4 1
Wheat straw	14.3	3 0	2.9	36 9	40.0	1.2	4 6
Pasture grass	80.0	3.5	2.6	9.7	4.0	0.8	2 0
Red clover (before bloom)	83.0	3.3	2 5	7.0	4 5	0.7	1.5
Potatoes	75.0	2.1	1.3	20.7	1.1	0.2	0.9
Mangels	88 5	1.2	0 4	3.2	1.0	0.1	1.0
Swedes	89.3	1.5	0.7	7 3	1.1	0.2	0.6
Turnips	92.0	1.0	0.5	5 2	0 9	0 2	0.7

* Thin hard-pressed cakes contain 8–10 per cent, thicker cakes 11–13 per cent., and some Russian cakes 14–20 per cent.

Many farmers are deterred from giving their milch cows a sufficiently liberal allowance of cake by the fear that the flavour of the linseed or other oil will be communicated to the milk. There are, however, unless excessive quantities be given, really no grounds for this apprehension, which owes its origin to erroneous conceptions of the use and destination of

the food-stuffs, and the very natural supposition that the fats absorbed with the food would be excreted in the milk. The fact, however, is that the fat ingested is wholly burned up and utilised in the production of energy and heat, or if in excessive quantity the surplus passes away unchanged with the fæces, none of it being stored in the tissues or entering the secretions. All such fats are formed afresh in the living organism from the albuminous constituents of the food, and it is the richness of the food in these that to a great extent determines that of the milk in fat, provided always that the non-nitrogenous starches and fats are supplied in quantities sufficient for the production of energy and heat, relieving the organism of the necessity of using any of the albumen as fuel, and enabling it to employ all that is not wanted for the repair of the tissues in the formation of fat, whether in the body or in the milk. In the relative proportions of the albuminous and fatty constituents of cotton and linseed cakes consists the superiority of the former, alike in stock and dairy farming, while the volatile, sapid and odorous principles present in roots and in fermented foods are very apt to pass unchanged into the milk, and to impart to it their characteristic taste; the same thing, however, occurs when excessive quantities of oil cake are given, due not to the oil itself but to the presence of similar odorous bodies, which are not met with in cotton cake.

In Norway, as is well known, the cows are, especially in winter, fed largely on **fish**, and if these be not quite fresh, or such as mackerel be used, the milk, as might be expected, acquires a fishy flavour. But at the Agricultural College at Aas and elsewhere, this is obviated by the employment of **herring meal** in the proportion of two parts to one of maize flour. The fish, perfectly fresh and clean, are dried, preferably in vacuum pans, at a temperature too low to cause frying, or the development of strong smelling products of the fat, and when thoroughly desiccated, are ground in a mill, the result being a fine odourless powder resembling oatmeal in

appearance. This mixed as required with half its weight of maize-flour, which supplies the starchy matter, is greatly preferred to oil cake, and considered superior even to cotton cake, which it closely approaches in its chemical composition, while it has no effect whatever on the taste of the milk.

There can be no question as to its high nutritive value and digestibility, and it would seem well worthy of a trial in this country, if only its preparation were conducted with the greatest care.

Locust beans, though but recently introduced and as yet by no means widely used are certainly the most valuable addition to the resources of the dairy farmer that has been made since the appearance of cotton-seed cake in the market. Finely ground and mixed as wanted with a like or smaller proportion of some cereal meal or bran to supply the starchy matter, it rivals decorticated cotton cake as a milk-producing food, being rich in albuminoids (legumin), though less so in fat than cotton and still less so than linseed cake.

Artificial foods.—The value of sugar or molasses as an adjunct to other food is undoubted, and the difficulty of finding a suitable vehicle has alone stood in the way. Recently, however, two foods have been put on the market, and supported by glowing testimonials as to the success that has attended their use for dairy stock and stable purposes. Analyses of each, by the same eminent chemist, have been published; but while the manufacturers of one do not hesitate to make known its composition, those of the other are reticent in the extreme, and maintain the strictest silence as to the vehicle.

The former of these is called *Sucrema*, and is prepared in two slightly different forms: No. I. being equally applicable for all domestic animals, while No. II. is specially designed for horses. The chemical composition of No. I. is given in an analysis by Dr. Bernard Dyer as—

Water	17.20	Mucilage, digestible fibre, &c.	17.85
Oil	1.53		
*Albuminoids	16.88	Woody fibre	7.77
Sugar	30.60	Mineral matter	8.77

* Containing nitrogen, 2.7

The ingredients consist, in addition to the sugar, of Cleveland linseed meal, decorticated cotton-seed meal, and maize straw, finely comminuted by specially constructed apparatus. Of the albuminoids 12.5 to 14 per cent. are digestible, leaving only about 2–3 per cent., or, together with the woody fibre, about 10 per cent. of the total weight indigestible.

Molassine is a similar preparation of a like soft fibrous or mealy texture, but much darker in colour and of a more treacly taste, from the different quality of the molasses employed in its manufacture. Dr. Bernard Dyer's analysis of molassine gives as its chemical composition—

Water	19.23	Mucilage, digestible fibre, &c.	19.78
Oil	1.06		
*Albuminoids	7.94	Woody fibre	6.37
Sugar	35 70	Mineral matter	9.42

* Containing nitrogen, 1 27

It is therefore somewhat richer in sugar, but very much poorer in albuminoids, of which it contains less than half the proportion present in Sucrema, the nitrogen amounting to 1.27 per cent. against 2.7 per cent. in Sucrema. The basis appears to be peat-moss litter, the nutritive value of which is very doubtful. Each may be given to milking cows in the same quantity as cake, the proprietors of Sucrema recommending two to four pounds, and of Molassine five pounds daily.

THE DIGESTIBILITY OF FOODS

Few if any articles of food are wholly digested, for not only do most contain structures, as matured woody fibre, which is in the highest degree resistant to the gastro-intestinal secretions, but of those constituents that are in themselves the most digestible, a certain portion always escapes

unchanged, a proportion increasing with the quantity of the particular food, and, a fact of the greatest importance, increased by the addition of a large quantity of a more easily digested food-stuff; thus the digestion of albumen is diminished by the addition of an excess of starch, though the converse is not observed. This, as a principle, is universally true, but differs in details with different animals, and to a less degree among individuals of the same species. Dr. E. Wolff, in his great work *Die Ergahrung der Landwirthlichen Nutzthieren*, and the supplement thereto, has worked out the question of the utilisation and waste of the albuminoids, fats, and carbohydrates respectively in all the chief foods, under different conditions for the horse, ox, sheep and pig. His results, which are full of interest, represent all that is known at present of the subject. Having determined the percentage of these constituents in the several articles of food, and recorded the weight of each food consumed by the animal, he calculated that of the albuminoids, fats, and carbohydrates ingested. Then, collecting, analysing, and weighing the solids of the excreta, which represented approximately the amount escaping digestion, he estimated from the difference between this and the quantity ingested, the proportion of each that had been actually assimilated or utilised, whether for repair of the tissues or the generation of heat and energy; which, reckoned as parts per hundred, he called the "co-efficient of digestion." It is this, rather than the mere composition of a food, that gives its nutritive value, while this again, compared with its cost, determines its economic value.

Of the total solids in hay and straw, not more than fifty to sixty per cent. is digested, against seventy to ninety per cent. of those in cereals, pulse and cakes, with the exception of undecorticated cotton-seed cake; and the nitrogenous substances, the fats and the carbohydrates in the two groups show, on the whole, the like differences. The digestibility of the albuminoids in hay and straw varies directly as

the quantity present in a given weight, and that of the fibre depends on the relative proportions of the more digestible forms of cellulose, which has the same formula as starch, $C_6H_{10}O_5$, and of the more indigestible lignin, which is richer in carbon. Roots make up to some extent for their low nutritive value by their higher digestibility; and potatoes, consisting mainly of starch and cellulose, are almost wholly digested. The digestibility of grass, clover, lucerne, &c., is not appreciably diminished by their being made into hay, provided the process is conducted under favourable conditions, but is mainly dependent on the luxuriance and maturity of the crop, being greatly impaired by age through the conversion of cellulos into ligneous tissue. Oil or cotton cakes, or pea and bean flours, foods rich in nitrogenous and fatty matters, may be freely given along with hay, chopped straw, &c., but the addition of starch or sugar in proportions exceeding ten parts, or of potatoes exceeding seventy-five parts to one hundred of the dry fodder seriously reduces the digestibility of the latter, especially of its nitrogenous constituents. Cereals contain a large amount of starch, but its effect is counteracted by the accompanying gluten so long as the ratio of albumen to the total weight of the food does not fall below the proportion of 1 : 8.

It is usual, especially in the Midlands, for dairy cows to be turned out to graze throughout the greater part of the year, but the practice should not be followed without some precautions. Thus they should not be turned on to a pasture too early in the spring, before the grass is long enough for them to grasp it with their tongues; they should, so far as is practicable, have a change of pasture from one meadow to another, or from different parts of the same; beginning with the inferior and proceeding to the richer, and where a pasture is damp or fenny it should be avoided until the weather is dry; the cows, too, should be watched, and if they seem to be suffering from the wet grass they should be removed or provided with an ample supply of dry hay or other

fodder. Where there is much clover with the grass cows are very apt to eat to excess and become *blown*; this may be prevented by giving them a good feed of dry fodder before entering the field or by moving them after a few hours to other pastures. The number of cows that may be turned on to a given pasture depends on the character of the grass; if too few, much of the grass will run to seed and become unpalatable; if too many, it will be kept too short for them to bite it, but the number should be such as to maintain a constant and sufficient growth of young blades, bearing in mind that grass is at its best from midsummer to August, though on good land and with a fair amount of rain the aftermath of September is nearly as good.

Soiling or stall feeding of cattle in summer with green fodder cut daily, though not in general favour on account of the additional trouble and labour involved in cutting and cartage and in the cleaning of the stalls, presents many and great advantages over free grazing. There is a great saving in the land required and the food consumed, while the waste is reduced to a minimum. Cattle in the open field trample down and spoil as much grass as they eat; they allow some plants to run to seed and become distasteful that, if presented to them while young, they would have eaten greedily; their preference for young herbage leads them to graze and regraze the same area, while passing by such patches as have already become rank and coarse; and, lastly, they will consume with relish, when cut and mixed with other plants and grass, many things as cow-parsnips, nettles and thistles, that they would have avoided or passed by in the pasture. In fact, the number of cattle that can be supported, and better supported, on a given area of land under a system of stall-feeding and soiling has been variously estimated as twice, thrice, or, by Dr. Thaër of Hanover, as four times as many as could be grazed on the same. If the last figure be too high, the first underrates the gain. An incidental advantage is that such rich appetising fodder as clover and lucerne can be given in

the most wholesome and suitable quantities along with others, thus avoiding the risk of blowing. The fodder for the evening meal, at any rate in wet weather, should be cut in the morning, and that for the morning's in the previous evening, and stored in a clean, airy place meanwhile. This system admits of a judicious mixture of foods according to the season and state of the crops, unattainable when the cows are turned out to grass. The larger bulk and richness of the dung produced, as Dr. Wolff has shown, under these conditions attests the better nutrition of the animals, but this must be returned to the land from which it is derived, otherwise the pastures will be impoverished, for cows when grazing deposit thereon the excreta resulting from the grass they have consumed, as well as from any other food that may have been given them in addition.

Under shelter cows are protected from cold nights, from rain and chilling mists as well as from the excessive heat of the sun and the attacks of flies, but the sheds in which they are confined in summer should be open, for though they do not, like horses, require much exercise, an abundant supply of fresh air is essential to the maintenance of their health; and in insufficiently ventilated buildings they become very prone to tuberculosis if any diseased individuals should chance to gain admission to the herd; they should therefore be turned out to exercise and to water for an hour or two morning and evening, weather permitting. This may be done conveniently at the times of milking, with the incidental advantage of avoiding the exposure of the warm milk to the emanations rising from their dung. These intervals may be utilised for sweeping and washing out the stalls.

Roots should be chopped, not given whole, since from their size and globular form they are not easily seized by the jaws of animals having no upper incisors or canines whatever, and a cow, after nibbling and dropping a root several times, is apt to leave it in disgust. That straw must be chopped and cake crushed small is too obvious to be insisted on.

Mr. Quincy, the most ardent and intelligent advocate of summer soiling in this country, concludes from long experience that one and a half rods of average land under cultivation will produce enough green fodder for a cow for one day; and assuming that the crop will remain succulent for ten days, fifteen rods will be required for that period. If any larger area be devoted to the purpose as a provision against bad or dry weather, the surplus will be available for hay to be used for winter feeding. The most useful crops he considers to be oats, barley and Indian corn, though lucerne, millet, cabbage, and the tops of carrots, turnips or beet, may also be employed.

Before the end of May, when cows are usually turned out to pasture, no green food is available for the purpose, though winter rye may be sown in the autumn for cutting during the latter half of that month. From the end of May to the beginning of July he uses grass, especially that from road sides, from under trees, and such-like coarse grass undesirable for making hay. To keep up a succession of fresh fodder for soiling during summer and autumn, he sows the above-mentioned crops at the following intervals:

(1) early in April, oats at the rate of four bushels to the acre.

(2) the third week in April; and again (3) early in May, barley or oats in like manner.

(4) the second and (5) the third weeks in May; and (6) the first week in June. Indian corn (the flat southern kind being the best) in drills at the rate of three bushels to the acre.

(7), (8), and (9) about the 15th and 25th of July; and early in August, barley, four bushels to the acre.

(1) will be ready for cutting early in July, and remains succulent till the middle of the month; (2) from the middle to the end of July, and (3) during the first half of August. The sowings of Indian corn, (4) (5) and (6), will in succession supply excellent fodder from the middle of August to the

end of September, and the later sowings of barley, (7) (8) and (9), will keep up the supply till early in November, when roots and their green tops, in the first instance, become available, and continue so, with the addition of hay, &c., throughout the winter and early spring.

Soiling, however, to be successful requires good soil and moisture, so that on dry hilly lands it will be better to adhere to the old practice of grazing. On such lands a certain amount of manure, of which the liquid from the tanks into which the dung from the cow-sheds is, or ought to be, washed is the best, will be requisite, since much of that dropped by the cattle is wasted, devoured by the grubs of dung flies and beetles, or washed by the rain into ditches, while the dried masses left on the ground destroy the grass beneath them.

Some farmers, fully recognising the connection between the food supplied to, and the milk yielded by, the cow, and the economy of feeding a cow in milk liberally, seem to grudge any expenditure beyond a mere subsistence diet to those that have been run dry previous to calving. This is a great error, for if straw and roadside grass are not sufficient to maintain a cow in milk, still less are they for one in calf. Not only is she unable to support the growth of the young one in her uterus, save at the cost of her own tissues and energy, but a period of semi-starvation tends to unfit her from resuming the function of lactation after the birth of the calf. In fact, very little, if any, difference should be made, and if it be deemed expedient to use up inferior fodder in this way, it should be supplemented with two to four pounds of some more nutritious food, as cake or roots.

It is admitted by all that as a summer food for milch cows nothing can surpass good grass growing on natural pasture; but when this cannot be had, or the supply is insufficient, tares, lucerne or clover, either cut or eaten off the ground, are excellent substitutes or supplementary foods. Beans, "kibbled" or crushed, are a valuable addition, at the rate of 3–4 lbs. a day, to ordinary or poor pasturage.

In winter good sweet hay takes the place of fresh grass as the staple article of diet, the supplementary foods being oil or cotton cake, swedes and crushed peas or beans, which give the richest milk; mangel and potatoes are nearly as good. A bushel of potatoes added to hay is said to equal any pasturage.

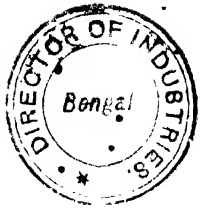
Roots.—The weight of these crops is out of all proportion to their nutritive value, since they consist of water to the extent of 90 per cent., against 80 in fresh grass and 10–14 in "dry" foods of all kinds. But they are indispensable during the winter months, when they take the place of meadow grass and other green food. Swedes present several advantages over turnips, especially in the ratio of root to the leaf. At Rothampsted two equal areas treated alike were found to yield respectively ten tons of turnips and twelve tons of swedes, the top growth in the former amounting to over six tons, and in the latter to one. Indeed, there seems little reason why, save on heavy soils and in cold situations, swedes should not wholly supersede other kinds. Swedes are somewhat later in maturing, and are in the best condition from November to March, while turnips may be available as early as October.

Mangels and parsnips contain, when ripe, a large amount of sugar, but this is not formed until a late period, and in the case of parsnips seems to be favoured by frost. Parsnips are rarely used in this country, but in Jersey it is not unusual to give the cows 25 lbs. a day with great advantage to their production of milk. Mangels are not in prime condition before March, and if carefully stored they remain good until June. Swedes therefore provide a succulent fodder throughout the winter, and mangels take their place in the spring, until the meadow grass is fit for grazing and the cows can be turned out on those pastures that have not been reserved for hay. One root much used in Germany, and which has in recent years been growing in favour in this country, deserves special mention. It is the Kohl Rabi, a tuberous cabbage,

more nutritious than the common kinds, giving a peculiarly rich milk, and entirely free from the objection attaching to turnips, that of imparting a flavour to the milk. Turnips and cabbages are apt to give an unpleasant taste to the milk, but with the former this may be avoided by cutting off the crowns, pulping and steaming or boiling the roots, and giving them soon after milking only. All dead and damaged leaves should be removed from cabbages. Damaged or mouldy hay, or that which, having been cut when over-ripe, is hard and indigestible, should be steamed, but good sweet hay needs no treatment. Some farmers, however, object to roots altogether, giving hay and crushed cake only, with perhaps some crushed beans, and certainly roots should be used sparingly. When the milk is intended for making butter turnips should be avoided altogether.

Brewery grains, distillery wash, and silage must be condemned *in toto*; given for any length of time they act injuriously on the health of the cows, and even in quantities too small to have any such effect they render the milk easily prone to spoil and wholly unfit for infant feeding, causing diarrhœa.

The decorticated cotton cake too is preferable to the crude seed cake, which contains an excessive and wasteful proportion of indigestible fibre.



CHAPTER IV

DISEASES OF THE COW

It would be well if every cowkeeper had sufficient powers of observation and acquaintance with the symptoms of the more frequent diseases of cattle to recognise them when they occur, and to know when the illness in question is not one of those with which he is more or less familiar, so as to be able to form an opinion as to the necessity for calling in a veterinary surgeon, and not to be dependent on ignorant and prejudiced men. This is the more important as cows are far from being sensitive or demonstrative, so that while a horse shows by his whole appearance the least digestive or febrile disturbance, a cow may retain her appetite and yield of milk undiminished when actually suffering from advanced and surely fatal diseases.

If more attention were paid by experts to comparative pathology many diseases would be distinguished which, from the similarity of their symptoms, are now confounded, and pass either under one name, or under local names often considered synonymous. Bacteriologists have already done some good work in this direction, especially in respect of the vesicular or pustular eruptions, but a wide field for investigation is open for further observation and experimental research.

The diseases of most frequent occurrence and practical importance are probably:

Acute Specific Diseases	*Anthrax, Pleuropneumonia, Foot and Mouth Disease.*
General Diseases	*Tuberculosis, Rheumatism, Septicæmia.*

DISEASES OF THE DIGESTIVE ORGANS	*Glossitis and Stomatitis, Impaction of the Gullet, Rumen and Omasum, Distension of the Rumen, Diarrhœa, Dysentery, "Jaundice," Hæmaturia.*
DISEASES OF PARTURITION	*Abortion, "Milk Fever," Septicæmia, Difficult Parturition.*
DISEASES OF LACTATION	*Vesicular and Pustular Eruptions and Fissures of the Teats, Mammitis and Abscesses of Udder.*
	"Cowpox," so called, and other cutaneous eruptions, including some diseases normally proper to man.
DISEASES CAUSED BY PARASITES	*Animal: Warbles, Lice, Tapeworms, Flukes, Filaria.*
	Vegetable: Actinomycosis, Ringworm.

Cattle Plague, which has been called bovine typhus from a certain apparent resemblance to the most malignant forms of that disease in man, is endemic in Eastern Europe and Western Asia, whence it has from time to time spread as an epizootic disease over Central and Western Europe, including these islands; but, thanks to the policy of stamping out, and the rigid exclusion of live animals from every possibly infected country, it is and has long been unknown in the United Kingdom.

Several fatal cases in the early sixties showed that it is communicable by inoculation to man, with immediately fatal results; but not otherwise.

Cattle plague attacks sheep and deer also. The incubation period is supposed to be from 4–8 days, though it has been said to be occasionally longer. Death occurs within a week, and the fatality is at least 90 per cent., the few survivor never recovering from the effects.

Febrile disturbance is observed 24 hours before the other symptoms; there is great prostration, the mucous membranes assume a pinkish, and later a purple or livid hue, most marked about the vulva; there are muscular twitchings and a husky cough; the pulse is not much affected at first, but later becomes frequent and full, then feeble, thready, and at last imperceptible. The respiration is "catchy," each inspiration is doubled, being interrupted by the muscular twitchings. There is diarrhœa, the evacuations being bloody, watery, yellow and offensive; the breath is foul. Emphysema of the lungs is followed by emphysematous or gassy swellings under the skin, the urine is scanty and albuminous, and the epithelium of the mucous membranes of the mouth, nose, and conjunctiva separates in flakes, leaving foul discharging ulcers. Nervous excitement rising to delirium passes into coma before death.

No treatment is of any avail, and attempts at preventive inoculation have utterly failed, since the artificially induced disease is not less virulent than that contracted in the ordinary way.

Anthrax, or splenic fever, is now rarely seen in this country, though prevalent in Eastern Europe, Asia Minor, South America, and elsewhere. The disease is so extremely and rapidly fatal that it is never introduced by living animals; but, owing to the extraordinary vitality and resistance of the bacilli and their spores, it is communicated by the agency of hides, fleeces, hair, and perhaps fodder. It is communicable to man by inoculation, not infrequently occurring among those employed in handling raw hides, or sorting wool and hair. The inoculated disease is also known by the name of malignant pustule, and is more localised and less fatal in man than in the domestic animals.

The carcases should be buried in uncultivated land, at a considerable depth, with the skin intact; and covered with quicklime, otherwise the spores will probably be brought to the surface by earthworms, and the herbage be the means of

infecting any cattle that may chance to eat it. In killing a diseased animal, the pole-axe, pithing, or a bullet shot into the eye should be used, so as to avoid needless spilling of blood, which, swarming with bacilli, would infect the soil or anything it might fall on.

The disease sets in suddenly, and death supervenes sometimes in six hours, mostly within twenty-four, and rarely so late as forty-eight from the first appearance of the fever. There are no external symptoms as eruptions or abscesses, though the internal organs are softened and congested. The glands about the throat may, however, be swollen if life be prolonged beyond twenty-four hours.

The animal stands alone, refusing to eat or move, with drooping head and dull expression, until it falls down to die. If compelled to walk the gait is stiff and staggering, and the muscles twitch and quiver. There may be a discharge of saliva, and bloody dung and urine. The secretions and excreta are all highly infectious.

No treatment should be thought of save instant slaughter. If the disease have broken out among cows in sheds, all that have not already sickened should be at once removed to an open thinly littered yard and watched hourly. Meanwhile, the litter, fodder, &c., from the infected sheds should be burnt, and the buildings washed down, floors, walls, roofs, mangers and all, with strong solution of sublimate, and finally lime-washed. Pastures in which any cows have been attacked should not be grazed until the following summer, or by horses only, nor may the grass be made into hay, and any spots infected by the excreta or blood of diseased animals should be covered with quicklime.

Toussaint considers fodder to be the usual vehicle, and slight wounds or abrasions of the mouth the mode of entry, the glands of the mouth and pharynx being first affected. In experiments with infected food he found that animals with sound mouths and soft food escaped, but those with abrasions of the mouth were attacked, as were those with

sound mouths if the food were harsh and contained prickles.

Where the disease has established itself in a country Pasteur's inoculations with an attenuated virus inducing a mild form of the disease, fatal in a small minority of cases, but conferring protection on the survivors, are expedient; but this is a contingency not likely to occur in these islands, where the disease appears sporadically only.

Splenic fever, or apoplexy, is the most virulent type of the disease, setting in suddenly and ending fatally in a few hours. The first intimation of its invading a herd may be the finding of several dead beasts in the morning. It may run to a fatal termination in two hours, and is rarely prolonged beyond twenty-four.

Glossy tongue is a local infection of a mild type; the tongue should be at once deeply scarified to avert choking.

Black Quarter was formerly thought to be of the same nature, but Dr. Greenfield finds a distinct variety of *Bacillus anthracis*, now described as *B. anthracis symptomaticus*. It commences in one of the limbs, which is hot, swollen and painful, the others being attacked in succession. Sanious, gelatinous, yellow or blackish, pulpy or fluid matter accumulates under the skin, escaping if incisions be made, and abscesses appear in different parts of the body. Very few recover.

Foot and Mouth Disease.—*Epizootic Aphthæ* is an acute specific fever, taking its name from the most marked external manifestation, an eczematous eruption on the mouth and feet. First introduced into this country in 1839 it was constantly present till 1886; it disappeared for six years, but since 1892 has broken out from time to time in various places. It is intensely infectious, and the bacilli, though not so resistant as those of anthrax, are possessed of great vitality, but it is by no means dangerous; recovery being the rule in this disease. The poison resides chiefly in the secretions of the mouth and nose, and the exudations from the feet, and

infection occurs by contact, by fodder, litter, &c., and the use of common drinking-troughs, and it may be by the hands of men in attendance.

After an incubation of two to five days the animal shows signs of ill-health, dulness, fever, the temperature rising even to 107° F., and "staring" of the coat. Next, a discharge of viscid, ropy saliva, and a noticeable uneasiness and fidgeting in the feet. Vesicles and small blisters appear in the mouth and nose, and along the line of junction of the hair and hoofs, which soon break, leaving small ulcers. In milch cows the eruption often appears on the udder and teats.

The milk is yellow, and steadily diminishes in quantity, but it may be suddenly arrested through the occlusion of the ducts by the extension upwards of the eruption, leading to retention of the milk, followed by mammitis or abscess.

As a rule recovery takes place in the course of one to two weeks, ordinary care and attention to the feeding being all that is required. The bowels are generally constipated.

Treatment.—The affected animal should be kept apart from others, and protected from cold and wet. The food should be tempting and of the most digestible character, as scalded corn and bran with a little malt meal, or any other sweet wholesome food that the animal may prefer. Two or three drachms of nitrate of potash in the drinking water twice or thrice a day will generally suffice to moderate the fever, and a dose of salts may be given as an aperient if there is constipation, but not otherwise.

The sore feet must be kept clean, and the treating of the ulcers will be assisted by lotions of boric acid, weak carbolic acid, and later of alum. Those in the mouth may, as a rule, be left to themselves, but if the breath be offensive or the ulcers do not readily heal, the mouth may be washed two or three times a day with a saturated solution of chlorate of potash, with enough permanganate to give the solution a rosy or lavender colour.

If the fever run high, or bronchitis or other complications threaten, good veterinary advice should be obtained.

In mild cases the cow continues to yield her milk as usual, but it contains the virus of the disease, which it communicates to man, giving rise to the same symptoms of fever, with eczema of the mouth, face, hands and feet, and in young infants a form of pneumonia which may prove fatal. Boiling, however, renders the milk comparatively wholesome by destroying the bacilli.

Pleuro-pneumonia is an acute specific fever, highly contagious and fatal. As with cattle plague, the law requires the immediate slaughter of all animals attacked, so that the only treatment is preventive, *i.e.*, the isolation under observation of such as have been exposed to the infection, the disinfection of sheds, &c., and burning of all fodder and litter that may by any possibility have been contaminated.

Introduced in 1842, it ravaged our herds from time to time until within the last five years, but appears to have been at length practically stamped out. Happily the bacilli, or rather micrococci, soon perish out of the living body, and disinfection becomes an easy task.

All evidence points to the entry of the infection by the respiratory tract only, except in the case of sucking calves, and individual animals present very different degrees of susceptibility. The incubation period has been variously estimated at from two weeks to as many months, probably three to four weeks is nearer the truth. The attack is preceded by a rise of 2° F. in the temperature of the body, two or three days before the other symptoms set in. These vary in intensity from the slight febrile disturbance to the most severe fever and dyspnœa. The pulse is at first full, 70 to 80 in the minute, but later it becomes thin and weak.

The breath is fœtid, the respirations hurried and difficult, and attended by *râles* that may not only be heard, but felt by the hand placed on the animal's side. There is an offensive purulent discharge from the nose, more or less

cough, and grunting respiration. Auscultation and percussion give the usual signs of pneumonic consolidation, catarrh and pleuritic effusion, and pressure on the loins causes pain. The appetite is lost, and constipation is followed by diarrhœa with offensive evacuations. The animal stands with its head stretched forwards, its mouth open and tongue protruded. The breathing becomes laboured and gasping until death ensues from asphyxia and blood-poisoning. After death the pleura is found adherent in parts, and its cavity filled with a yellowish fluid, very rarely with pus: there is often pericarditis also. Infective material carried by the lymphatics of the pleura and bronchial regions causes hæmorrhagic infarcts in their walls, and ulceration with occlusion or obliteration of the smaller vessels.

It not infrequently happens that the true nature of a case remains doubtful until the post-mortem appearances can be observed, or its infectious character is shown by its attacking one member of the herd after another in regular succession; for in mild cases the symptoms may not differ essentially from those of an ordinary catarrhal pneumonia. Acute tuberculosis, too, may closely simulate pleuro-pneumonia, as indeed may almost any disease involving the lungs.

N.B.—The normal temperature of the cow's body is 101° F.–102° F., somewhat higher than that of man, but it is less subject to great rises in febrile states. The pulse 70–80, and the respiration 15, are the same as in man.

DISORDERS OF DIGESTION

The complex structure of the stomachs, and the length of time occupied in the digestive process of ruminants, and above all of the cow, whose food is more bulky than that of sheep, goats and deer, render them peculiarly liable to disorders of digestion, due to the interference with rumination caused by the impaction of one or other cavity with food, or distension with the gases evolved in the fermentation of undigested food.

Tympany, popularly described as the cow being "hoven" or "blown," is the distension of the rumen or paunch with gases formed by the fermentation in the stomach of succulent food ingested in quantities too large for easy digestion. It is thus often caused by fermenting grains, raw juicy potatoes, rank luxuriant herbage, lucerne or clover, with which cows are very apt to gorge themselves, especially if it be wet with rain or dew, and it may follow a sudden transition from the dry food of winter to the green food of spring. Anything that interrupts the normal course of rumination, and thus causes the retention of undigested food in the paunch, and its fermentation, may induce tympany. It thus accompanies impaction of either stomach, and may be caused by presence of hair balls.

The symptoms are very evident, the abdomen being distended, in some cases, to an enormous extent, especially over the left flank, the walls of the belly being elastic to pressure with the hand, and when struck emitting a drum-like tone. Sour smelling eructations occur, the bowels are irritable, acting frequently, but little at a time, and the breathing is impeded in proportion to the degree of distension.

Treatment.—If the animal be much distressed, prompt relief is afforded by puncture of the inflated paunch with a trocar and canula designed for the purpose. She must be placed in a stall, and the operator standing on her left side plunges the instrument, which must be perfectly clean and bright, deep into the flank, four or five inches from the spine and at a point midway between the last rib and the haunch bone. It will thus enter the paunch, when the trocar, being withdrawn, the pent-up gases escape through the canula or tube, which should be left in for an hour, or longer, if any gas continues to form. Then a warm aperient of Epsom salts 1 lb., spirits of ammonia 2 or 3 oz., and an ounce of powdered ginger should be given, followed in two or three hours by 3 oz. of spirits of ammonia in three pints

of water. Further fermentation may be prevented by a tablespoonful of "chloride of lime" in a pint of water. No food should be allowed for twelve hours, but linseed gruel may be given freely. It is often a considerable time after such an attack before the power of digestion is fully recovered, and meanwhile great care must be taken in feeding.

Impaction of the Rumen.—A cow is said to be "maw bound" when the paunch is overfilled with solid food, and its walls so paralysed as to lose the power of expelling its contents. This condition may be complicated with tympany if the food be of a kind liable to undergo fermentation.

Symptoms.—There is enlargement of the abdomen, but not extreme, unless there be tympany as well. The drum-like sound is absent, and deep pressure gives to the fingers an inelastic doughy sensation, and is followed by pitting or depressions lasting for some little time.

The animal is dull, with a stupid expression, the pulse is full and frequent, the respirations hurried, and the pain causes her to be restless, grunting and grinding her teeth, while in severe or prolonged cases symptoms of engorgement of the brain are manifested by drowsiness or by great excitement, sometimes amounting to frenzy, or madness.

Treatment.—Operative treatment is unavailable, but a strong purgative must be administered promptly in the form of a draught of 16–20 oz. of Epsom salts, with four drachms of aloes and two ounces of tincture of gentian in two quarts of warm linseed gruel. If within twelve hours the bowels have not acted freely, a second dose should be given of about half the strength of the first. If the animal be also blown, the fermentation of the undigested food may be checked by half an ounce of chloride of lime in a quart of cold water.

The expulsion of the food from the paunch may be assisted by a little walking exercise so soon as the animal can bear it, and inflammation of the stomach averted by friction of the abdomen with turpentine in oil.

Impaction of the Omasum.—When the omasum, or third stomach becomes overfilled and distended in like manner with solid food, the cow is said to be "fardel" or "cluebound," a condition that, if neglected, may lead to inflammation of the organ, or "omasitis"; and the consequent congestion of the brain causes vertigo or "staggers." As tympany follows repletion with moist green fodder, so this condition is most often caused by a diet of coarse dry indigestible food, and especially when at the same time the animals have not a sufficient allowance of drinking water. It is not infrequent among cows grazing in parks, where the coarse autumn growth of grass is mixed with the dry bracken, dead leaves of trees, the fallen husks of beech nuts, and astringent acorns. An excess of chaff and straw, with an insufficiency of roots and other succulent fodder to correct it, may also induce this accident.

The symptoms are less evident than they are in impaction of the rumen, but constipation is very marked, and the motions are accompanied by slimy mucus. Food is refused and rumination suspended. The head is carried low, and the face has an expression indicative of dull pain. The animal stands obstinately still, or lies on its side with the head extended, glancing occasionally from side to side, grunting and groaning. If not relieved brain symptoms may supervene, with impaired sight, unsteady, rolling or staggering gait, or even symptoms of frenzy.

Treatment.—The constipation must be overcome by doses of Epsom salts and aloes, as in impaction of the rumen, or by castor oil, and the pain may be relieved by the application of turpentine, mustard, &c., to the right flank and belly. In all cases the aperient should be assisted by copious enemata of warm water three or four times a day, while draughts of thin warm gruel are poured down the throat. If there be much excitement of the brain cold water must be frequently douched over the head, and in bad cases blood may be drawn from the jugular vein.

Diarrhœa or *Scour* is, as in the human being, merely a symptom of any intestinal irritation, and, unless the cause of this be found and removed, drugging will be of little, if any, use. It may be set up by the paralysing effects of exposure to cold and wet on the digestive function, when the food acts as a foreign body, and perhaps undergoes putrefactive changes in the bowel. More often it is the result of errors in diet, unsound or decomposing roots, sour mashes, excessive quantities of undecorticated cake, or any indigestible irritating food; foul water, especially in summer, and even a sudden change from dry fodder to rank herbage, especially if accompanied by acrid plants such as are many of the Ranunculaceæ and Umbelliferæ.

Dysentery or *Bloody Flux*.—Probably, as in the case of man, two or more diseases attended with similar fæcal discharges, which in themselves are but symptoms, have been confused together. The dysentery that follows the continued use of sewage-polluted water is essentially the same as that which prevails in camps, insanitary villages and prisons, especially in hot climates, and bears almost all the characters of a communicable specific disease. But symptoms and consequences, practically indistinguishable from these, may follow prolonged intestinal irritation, and thus not only foul water, but unsound or indigestible food is said to give rise to it.

Symptoms.—The onset may be sudden, with all the indications of febrile disturbance, high temperature, quick pulse, dry mouth, rough coat, &c., also abdominal pain, often severe, and the frequent passage of loose watery evacuations, attended with straining, and containing not only mucus and blood, but shreds consisting of exudations of a fibrinous material, with more or less of the mucous or even submucous coats of the intestine exfoliated by the inflammatory process, and sloughing or gangrenous, emitting a most offensive fœtor; these shreds distinguishing true dysentery and colitis from the results of enteritis or other forms of diarrhœa.

In other cases the course of the disease is more gradual, and the symptoms are less severe. Chronic dysentery may be a sequel of the acute, or it may be chronic from the beginning, resisting treatment, and leading to emaciation, exhaustion, and death.

Treatment.—As a rule the medical treatment is unsatisfactory, for if extensive and deep destruction of the mucous lining of the bowel has taken place, the power of absorption from the intestine, which is quite as important and indispensable as that of excretion, is so far impaired that complete recovery is impossible, and the animal gradually wastes dying of slow starvation. To be at all successful the treatment must be begun betimes with a small dose (℥ij. to ℥iv.) of castor oil, and ℥ss. to ℥i. of laudanum. Afterwards every eight hours a draught of linseed tea containing carbolic acid gr. v., glycerin, and catechu ℥ij. with, if it appear desirable tr. opii ℥xxx. The food must be wholesome, light and digestible, as boiled oatmeal, or maltmeal, carrots or turnips, linseed gruel, or cake gruel, a little whisky being added if there be much prostration or emaciation. Until convalescence is complete the animal must be housed in a clean, warm, dry and airy stable.

Gastro-enteritis, or *White Scour*, is of frequent occurrence in calves, and results from a variety of causes, for the most part improper feeding or insanitary surroundings. Stale milk, sour gruels, or food good in itself, but given in dirty pails, and water polluted with excreta or much organic matter of any kind, decomposing roots or green fodder that has become stale, will alike give rise to this condition; and sudden changes of food; calves taken from the mother's teats to the pail are apt to gorge themselves to repletion, and too long intervals between meals in like manner lead to disturbance of the digestion.

The milk of the cow may disagree with the calf if her digestion is impaired by bad food or water, by the fatigue and excitement of railway journeys or any other cause, and

occasionally the milk of a cow other than the mother, especially that of old cows or such as have calved some time previous to the birth of the calf put to them, will induce illness in the latter. An atmosphere foul from accumulations of dung in the shed or from defective ventilation is a frequent cause, and the disease may follow exposure to cold and wet.

Symptoms.—The onset of the attack may be sudden or gradual, and its course acute or chronic, being determined by the nature of the causes. There is more or less febrile disturbance and prostration, the coat is rough, the appetite is lost, the calf is dull and inclined to lie down, the muzzle hot and dry and the mouth clammy, the abdomen retracted and the back arched. The most marked and indeed the essential feature is the character of the evacuations, which are frequent, pale yellow, and of a very fœtid pungent odour; at first they are fairly consistent but soon become semi-fluid, with much mucus, and curdy masses of undigested milk; occasionally they contain blood. Their passage is attended with straining and pain, indicated by grunting, moaning and grinding of the teeth.

Treatment.—The calf must be at once removed to a clean, dry, warm and well-ventilated shed, and wrapped in a blanket or woollen rug. One or two ounces of castor oil with a teaspoonful of laudanum should be given to clear the bowels of the offending matters, and to relieve the pain and irritability. When the oil has acted freely give every three hours two tablespoonfuls, *i.e.*, one ounce of the following mixture in half a pint of water—

Prepared chalk, one ounce:
Tincture of catechu, one ounce;
Tincture of opium, half an ounce;
Bicarbonate of potash, one and a half drachm
Whisky, one ounce; and
Cassia in powder, half a drachm; with
Water to make up eight ounces,

the whole providing for eight doses, which will be given in the course of twenty-four hours.

Drugs will, however, be palliative only, and may check, but will not cure, the disease, unless the cause be discovered and removed, whether this be an error of diet or insanitary or other conditions.

Hæmaturia, *Black Water*.—Called also, from the local conditions under which it sometimes occurs, Wood Evil or Muir Ill in Scotland, is an acute inflammation of the kidneys, caused by exposure to cold, or the consumption of acrid herbs, and also apparently by coarse indigestible food directly or indirectly irritating the kidneys, and causing the passage of blood with the urine, or leading to changes in the blood, the breaking up of the red corpuscles, the colouring-matter of which is dissolved and excreted by the kidneys, giving to the urine the red or blackish colour, whence the popular name is derived. When the red blood corpuscles escape as such the condition is properly called hæmaturia; but when they are disintegrated, and their dissolved contents only are passed, it should be described as hæmatinuria, or hæmoglobinuria, the former being caused by the circulation in the blood of matters irritating the kidneys; but the latter by more profound changes in the constitution of the blood itself, as in the black-water fever observed in man when suffering intense malarial infection.

It is most frequent in spring and autumn; cows that have recently calved are specially susceptible, and certain localities or pastures appear to favour its occurrence.

Symptoms.—Dulness and prostration, rough and staring coat, unsteadiness of the gait and movements, tremors and twitching of the muscles, cold skin, dryness of the muzzle and mouth, with pallor of the mucous membranes of the eyelids, mouth and throat. Loss of appetite and impaired digestion, and diarrhœa followed by constipation. Palpitation of the heart is very marked in many cases, and the dulness may be succeeded by excitement amounting to delirium. The urine is passed frequently and in large quantities, its colour being dark reddish or a deep blackish

brown like porter. On boiling it becomes thick and turbid with a heavy deposit of albumen.

Treatment.—The animal should be placed in a dry, warm, and airy shed, and enveloped in a blanket. The bowels and general congestion of the abdominal organs may be relieved by a good dose of Epsom salts with a little ginger. The administration of turpentine, though commonly practised, is of more than doubtful expediency, since it is an irritant to the kidneys, and tends to aggravate the congestion of these organs; indeed, the eating of the leaves of resiniferous trees may of itself be a cause of this trouble. Better far are large doses of spirits of nitrous ether, with nitrate or tartrate of potash in a gruel of well-boiled linseed cake, and copious draughts of strong linseed tea given with a horn several times a day, to increase the flow of urine while relieving the congestion of the kidneys, which turpentine is likely to aggravate. The prostration, if great, should be combated by boiled milk and eggs. Boiled oatmeal, maltmeal, sweet bran or pollards form a palatable and nourishing diet in all cases. A little salt and bicarbonate of potash may be advantageously added to the mash. When all symptoms of congestion of the kidneys have disappeared, but not before, convalescence will be aided by a dose of sulphate of iron with the food morning and evening.

Glossitis, or *Inflammation of the Tongue.*—The use of the tongue in the prehension of food, in consequence of the absence of front teeth on the upper jaw, renders it specially exposed to injury and irritation, as from thorns, stings and bites of insects or irritant juices of plants acting on wounds and abrasions, which may lead to dangerous swelling and even to sloughing of that organ. Inflammation of the tongue may be present in foot and mouth disease, and it necessarily undergoes a chronic enlargement when it is the seat of actinomycosis, known by the numerous tubercles on its surface, which soften into small abscesses and ulcers. But glossitis proper, in which the tongue is red, swollen, and

protruding, is a purely local affection, the dangers of which are suffocation from its pressing on the glottis behind, or mortification of the dry protruded tongue.

Treatment.—1 lb. of Epsom salts and if the bowels have not acted freely within twelve hours a second dose of ½ lb. At the same time the tongue should be punctured or scarified in half a dozen or more places with a sharp, clean scalpel, and the bleeding encouraged by warm fomentations.

Should no real improvement have taken place after twenty-four hours, it would be advisable to slaughter the animal, if otherwise healthy and in good condition.

Choking is rather an accident than an illness, though it may in rare instances depend on the presence of disease of the œsophagus. It is usually caused by a large piece of turnip or mangel becoming impacted in the gullet, or less frequently thorns, sticks or nails may become fixed and prevent the passage of food, as fish-bones occasionally stick in the human œsophagus.

Symptoms.—Frequent efforts at swallowing, choking cough, discharge of saliva, and suspension of the cud. The stomach may become distended with gas through the interruption of the digestive acts.

The seat of the obstruction if in the throat may be discovered by passing the hand beyond the root of the tongue in the gullet; the mass, if of considerable size, may be felt by manipulating the left side of the neck with one hand while steadying it with the other on the right; though when in the lower part it will not be possible to feel or reach it. In the second position attempts should be made to work it upwards by gentle manipulation, when as in the first it may be broken up, or removed by the hand, water poured down aiding in loosening it. Should these efforts fail the head must be held out straight, and a probang passed until the obstruction is felt, when by steady gentle pressure it may be pushed onwards, but no forcible or jerky pressure employed lest the walls of the gullet be lacerated or even ruptured.

If the cow be much blown it may be necessary to puncture the paunch to prevent suffocation during the operation of forcing the obstruction or from the futile efforts at vomiting.

Jaundice is not, properly speaking, a disease, being a symptom or consequence of any condition involving obstruction of the bile-ducts, as tumours of the liver, by parasites in the ducts, or most frequently gall-stones. It occurs also in some contagious diseases, but may often result from simple catarrh of the duodenum leading to closure of the aperture of the common bile-ducts. This last condition is the only one amenable to medical treatment, and may be relieved by aperient doses of Epsom salts, and the addition of nitrate of potash to the food, with infusion of gentian or calumba with small doses of strychnine. The diet should be light and digestible, and gentle exercise will assist in restoring the action of the liver.

Abortion, or *Slipping*, is a common accident to which some cows seem specially prone. It may be caused by violence, fright, fatigue from railway journeys, or over driving, from violent purgation or drugging, and from eating the leaves of juniper, yew, or ergotised grasses. There is a popular notion that it is contagious, but this is impossible, and the occurrence of the accident in a number of cows in succession is probably to be explained by their having partaken alike of the same poisonous plants. It frequently accompanies foot and mouth disease, pleuro-pneumonia and acute tuberculosis.

Treatment.—It most frequently comes on without warning, but if any premonitory indications be observed the cow should be placed alone in a dark stable, the utmost quiet maintained, an opiate given to allay the uterine irritability, and the diet restricted to mashes of bran. To prevent it, cows advanced in pregnancy should be dieted with care, constipation and purgation alike avoided, as also all over exertion, fatigue, and excitement. Damp rank pastures

should be shunned, especially if there be any suspicion of the grass being ergotised, and yew or juniper trees should be fenced off.

Milk Fever.—Parturient apoplexy mostly attacks cows at their third or fourth calving, good milkers of plethoric habit, especially if overfed, being most predisposed to it. It usually sets in between twelve and thirty-six hours after the birth of the calf, with cessation of rumination, suppression of the secretion of milk, and dulness; then the gait becomes unsteady, the hind legs are in constant movement, the animal staggers, and at length falls helpless on the ground, with its head turned to one side and the eyes closed, when the stupor passes into complete unconsciousness, ending in death. The pulse is quick throughout, the breathing is heavy and laboured, and the stomach sometimes distended with gas. The condition is one of congestion of the brain, and ultimately of hæmorrhage into its substance, rightly described as parturient apoplexy, the suppression of the milk being an effect, not a cause, as the popular name would suggest. If the animal be of very full habit, bleeding may be of use in the earliest stage; but as soon as the nature of the attack is suspected a strong purgative of Epsom salts, with aloes, or, better still, croton oil, should be administered. The body should be enveloped in blankets made hot before a fire, while cold water is poured over the head or ice bags tied on. But a still better method of applying cold is by irrigation. A large pail or tub of cold water, containing blocks of ice, should be fixed at some height above, as on the rafters of the shed, or the cistern for the supply of the drinking-troughs may be utilised. From this a continuous and steady but thin and gentle stream of the ice-cold water is brought to bear, by means of some kind of siphon, on the head of the animal, covered with a light sheet of calico or muslin, such as is used for straining the milk, in order to spread the water uniformly over the surface. A wet towel, folded or rolled lengthwise, or a long bundle of tow will answer well, but better still would

be a length of rubber hose or tubing with a garden rose fixed to the end, the tube being first filled with water, and the cock kept closed until it is placed in position, with its other end dipping to the bottom of the pail or cistern. This contrivance presents several advantages over the other, the length of the tube rendering the position of the reservoir immaterial, save as regards its elevation, and therefore the cistern is available for the purpose, and its flexibility permitting of the adjustment of the stream to the movements of the animal, while the strength of the flow can be regulated by the stopcock, while the rose supersedes the need for a muslin or other spreader on the animal's head. The cistern, too, has an advantage over any pail, in the fact that the volume of water being larger, and the supply being, if not automatic, easily made to keep pace with the outflow, the temperature can be maintained at or near the freezing-point so long as any ice remains unmelted. Meanwhile depression must be combated and the circulation maintained by stimulants, gin or whisky and ammonia; and turpentine liniment may be rubbed on the spine. The animal should be turned over from time to time, and not allowed to lie too long in one position.

It is said that much success has followed injections of iodine into the udder,* though it is not clear why that region should be chosen unless on account of the looseness of the subcutaneous connective tissue.

Rheumatism.—*Chine* and *joint fellon*. Cows occasionally suffer from both the acute and chronic forms of this disease; the former, as in the human subject, often leading to grave or even fatal affections of the heart. Some cows appear to have a constitutional tendency to the disease, which is brought on by exposure to cold and wet, or to keen easterly winds, especially when heated by driving. Acute rheumatism, or rheumatic fever, sets in suddenly with fever, loss of appetite, roughness of the coat, and dryness of the

* "Journal of the Royal Agricultural Society," Third Series, vol. x. (1899), p. 154.

muzzle. The bowels are constipated, and the urine high coloured. The joints are swollen, the swellings being hard or fluctuating, first one limb and then another being affected, and the swelling reappearing after having subsided for a time; the pain in the inflamed joints is great, and the animal, unable to stand, lies for hours in the same position. The symptoms of chronic rheumatism are similar but less severe, the fever and swelling being less marked; indeed, these symptoms may be absent, and the pain alone noticeable.

Treatment.—The bowels must be opened by a good dose of Epsom salts, and the diet restricted to bran; iodide of potassium and bicarbonate of potash should be given three or four times a day, and if the symptoms are not relieved the addition of colchicum may be tried. In acute cases with much fever aconite and salicylate of potash should be given with the bicarbonate, and the pain relieved by laudanum, or, better, injections of morphia, which are less likely to constipate and give much speedier relief than opiates administered by the mouth. The inflamed joints should be fomented with hot decoction of poppy heads, and then wrapped in flannel. In the chronic form, and in the acute when the swelling has subsided, liniments of opium and belladonna, or of aconite, belladonna and camphor. Co. should be frequently rubbed on the affected joints. The animal must be kept quiet in a dry, well-littered box, free from draughts. Should the swelling persist after pain has subsided, blisters may be applied once or twice to the affected joints.

Garget or **Mammitis** is an inflammation of the udders, attacking one or more of the quarters, and following injuries as blows or bruises, exposure to cold easterly winds, or over-distension of the udders with milk; it occurs also as a complication of foot and mouth and other diseases. The affected quarters are hot, swollen, and very painful, the milk drawn from it is curdy, and may contain pus or blood, and there is general febrile disturbance.

Treatment.—Give a full dose of Epsom salts, and a smaller

one on the following day or two. Draw off the milk from all the quarters three or four times a day. Foment the bag well morning and evening, and sling it up with a broad piece of flannel with four holes cut in it for the teats, fastening it over the back. Should abscesses form they must be opened. If the bag remains hard after the inflammation has subsided, it should be well rubbed with soap liniment two or three times a day.

Vesicular eruptions of the udder are not uncommon, and are often erroneously supposed to be cowpox, but are rather of the nature of eczema or herpes, though occasionally communicable by the hands of the milkers. When they occur the milk should be carefully drawn, but not used, and the udders dressed with boric ointment, as should the simple chaps and fissures caused by exposure to cold winds.

Actinomycosis. — *Wooden tongue.* — This interesting parasitic disease, common to man and cattle, is caused by the growth in the bony or muscular tissues of a "ray" fungus, "actinomyces" akin to the "madura foot" and other fungous diseases of the tropics. It was first recognised in cattle by Bollinger in 1876, and by Israel in man the following year; Ponfick, in 1879, showing the identity of the disease in man and beast; and its communicability by inoculation from artificial cultures as well as from the living body, was experimentally demonstrated by Johne, Wolff, Israel, and others in 1880–85. It was not until 1882 and 1885 that Mr. Fleming and Mr. Knight Treves recognised its existence in this country in cattle and man respectively.

In neither, however, is it a new or rare disease, for so long back as 1826 Leblanc described cases in cattle as osteo-sarcoma of the jaw, and in 1845 and 1848 Langenbeck and Lebert depicted the granules in "scrofulous" abscesses in man with great accuracy, without suspecting their true nature. In 1868 Perroncito and Rivolta, and in 1870 Hahn, recognised the fungoid or parasitic character of the granules, but looked on them rather as of accidental occurrence than

as the essential cause of the disease. In fact the tumours and abscesses have been often seen, but were always and are now occasionally supposed to be tuberculous or cancerous; and it is certainly at least as frequent in this country as anywhere, for Crookshank declares that in some herds he has found from one to eight per cent. of the animals affected with some form of the disease.

Source of the infection.—The fungus grows naturally in certain grasses, especially those belonging to the genus *Hordeum*, the barleys, the sharp awns of which are very efficient means of inoculating it: hard straw and splinters of more or less decomposing wood may act in the same way.

As might therefore be expected, the parasite enters the body almost exclusively by the mouth, and fifty-five per cent. of the cases present the disease in some part of the head, neck or tongue, about thirty-five per cent. in the viscera of the trunk, and not ten per cent. on the skin and elsewhere.

The course of the disease is of necessity slow, but acute symptoms may supervene in consequence of septicæmia or blood poisoning. There is nothing distinctive in the tumours themselves, which take their characters from those of the parts in which they are situated. In the muscles and viscera they form agglomerations of small abscesses; on the skin small soft rounded tumours resembling sarcomata, which burst, leaving ulcers that do not heal: in the lungs they set up bronchitis, pleurisy, &c., and with the cough and purulent expectoration closely simulate tuberculosis. In the bones they are also suggestive of the same, but while in man the process in the jaw is rather one of necrosis, there is in the cow so active a growth of fibrous tissue that the tumour may attain an enormous size. But though clinically the diagnosis is difficult, a microscopical examination of the pus discharged, or of some of the contents of the abscesses obtained by exploration, leaves no doubt. The granules, $\frac{1}{50}$ to $\frac{1}{25}$ inch in diameter, crushed or teased out in water, may be examined for merely diagnostic purposes with a microscope magnifying

no more than 100–300 diameters, when they will be seen to consist of a nucleus from which wavy filaments radiate in all directions (whence its name), terminating in club-like ends, which in the bovine disease are in such close contact as to form a hollow globe clearly recognisable when the filaments themselves have been obscured by calcification.

Treatment.—All attempts at "dispersing" the tumours by counter-irritants, or external applications of any kind, are useless, the only drug of any avail being, as Thomassen discovered in 1885, the iodide of potassium, given in large doses amounting to two to four drachms in the twenty-four hours (thirty to sixty grains per diem in the human patient). This, if continued long enough, will lead to the extinction of the fungus. When the deposits are seated in internal organs it only is available; and where the disease is in the tongue the action of the drug is enhanced by the fact of its being excreted in the saliva. But when the tumour is in the jaws or otherwise easily accessible to surgical procedure, the cure may be effected by a single operation, and the iodide given for a much shorter time. Decayed teeth, the crypts of the tonsils, and wounds or fissures of the tongue, are the easiest channels of entry, and explain the prevalent distribution of the disease.

Warbles are small rounded elevations on the skin, mostly of the back and loins, varying in size up to that of a small cherry, with an aperture at the summit. Each contains the grub of the warble, or bot-fly, which, when full grown and about an inch in length, makes its escape tail foremost and falling to the ground is transformed into a chrysalis, from which in a short time the fly emerges, and at once begins its attacks The egg-laying period is from June to August, but in hot seasons may begin earlier. The life of the grub is nearly twelve months, and the duration of the chrysalis stage three or four weeks.

Warbles, if in large numbers, give rise to grave constitutional disturbance and much suffering; but in any case

they detract from the value of the hide, the position of each being marked by a perforation as if punched out through the whole or a part of its thickness, and when these are closely crowded the skin is practically worthless.

The grubs may be squeezed out of the sac, or killed by inserting through the aperture a large needle or probe smeared with mercurial ointment; but the death of the grubs, if large and numerous, may be followed by blood-poisoning from putrid absorption.

The fly is two-winged, about half an inch in length, somewhat hairy and banded with black, brown and yellowish, not unlike an humble bee; while the plain brown chrysalis may be found under stones and clods in places where cattle graze.

The flies are most troublesome in hot sunshine, but do not seem to follow the cows over water, hence the advantage of providing shelter and of allowing cows to wade in water during the heat of the day.

Since the maggots fall and the flies come out within a month, it would be well to avoid such infected pastures for one summer, while children might be usefully employed in searching for and destroying the chrysalises, but it is better to attack the grubs so soon as their black tails are seen in the warbles. They may also be destroyed, without squeezing, by rubbing in any grease, with or without the addition of sulphur or tar, so as to suffocate the maggots in their holes; while the attacks of the flies may be prevented by rubbing or washing the backs of the cattle two or three times during the summer with some strong smelling oily application, as 4 ounces flowers of sulphur, 1 gill spirits of tar, and 1 quart of train oil, or a mixture of tar, sulphur, carbolic acid and linseed oil. Even train oil alone rubbed over the back several times during the summer will often be sufficient, as would be paraffin or kerosene oils did they not evaporate too quickly.

The loss through warbles is estimated at several million pounds sterling per annum.

Flukes are a frequent cause of anæmia in cattle. The presence of the parasite in the liver irritates that organ and unduly stimulates the secretion of bile and the glycogenic function. No treatment is possible, but since the larvæ enter the body from water, and usually when cows have been grazing in low-lying meadows flooded in wet weather, the presence of the parasite in any of the animals should be followed by the avoidance of such infected pastures. The flesh of these cattle is not unfitted for consumption, except the liver, which should, of course, be destroyed.

Lice rarely attack healthy, well-fed animals unless they are stalled with weakly ones already affected, and they are easily destroyed by an application of oil with some sulphur, and perhaps a little oil of tar.

Ringworm is a vegetable parasite, a form of mould growing in the substance and roots of the hairs, which break off when the skin around becomes dry, scaly, bald, or, if the irritation be considerable, scabby. It is very easily communicated from one animal to another, especially among calves, and the spores adhere to the walls of buildings and to everything that has been in contact with the affected animals.

Treatment.—The stalls or sheds must be evacuated and cleared out, the litter and fodder burnt, the walls limewashed, and all furniture, mangers and floors washed down with a fairly strong disinfectant.

After the scurf has been removed by scrubbing with warm soap and water, and the hair around the patches shaved, these may be dressed with a mercurial ointment or a solution of sublimate, or painted with tincture of iodine for a few successive days. Should these leave any soreness, boric acid or zinc ointments will be found very healing.

Tuberculosis.—This, the most important of the specific diseases common to man and beast, is everywhere more or less prevalent among dairy cattle. Some breeds, as the Jerseys, seem specially prone, probably from the fact that

their tender constitution necessitates their being housed for nine months in the year, since the same proclivity is observed among the high-bred tender stocks in Germany, while the disease is practically unknown among Highland oxen and the herds that roam the prairies of North America or the pusztar and steppes of Hungary and Russia without shelter even in the coldest winters; but it is said to be very general in New Zealand, where they are always in the open air and the climate is perfect. The Danish and Holstein cattle, especially the cows, appear, from the reports of the German public slaughter-houses, to suffer more than those of many other districts, and in some parts of this country the proportion affected in some degree, as judged by post-mortem examinations, has been roughly estimated at from 20 to 40 per cent., or from the tuberculin test at near 60 per cent. During life the symptoms may be latent, and unrecognisable by the eye until the disease is far advanced; so that any animal that remains persistently dull, loses its appetite, gets thinner, or coughs continuously, should be carefully examined and tested, while its milk should on no account be sold without having been sterilised.

Hard enlarged glands in any part of the body, especially if painless, are always suspicious, and should any such lumps be seen or felt in the udder, the milk should not be sold under any pretence or with any precautions, nor given to calves, nor to pigs, unless it has been boiled, until it has been found to be free from tubercle bacilli, and the cow has failed to react to the tuberculin test.

The disease, once introduced into a herd, spreads surely if slowly, chiefly through the infection of troughs and mangers, walls, fodder and litter with the mucus from the nose and throat, and that coughed up from the lungs of the affected animal.

A cow presenting any suspicious symptoms should be separated from the rest, and the shed or stalls recently occupied by her thoroughly cleansed, washed down and

lime-washed. If she react to the tuberculin test she should be quickly fattened for the butcher, which is easily done in the early stage of the disease; the lungs, however, should be destroyed, though the flesh will, if the case has not been neglected too long, be perhaps none the worse.

POSOLOGICAL TABLE

Acidum Nitr. dil. ℥i ℥i
„ Hydrochlor. dil. ℥i–℥i
„ Gallicum gr. xxx ℥i
„ Tannicum gr. xxx.–℥i
Aconiti Tinct. ♏xxx
Aloes ℥ss ℥i
Albumen ℥ii ℥iv
Ammonia Carb. ℥ii
„ Liquor. ℥ii diluted
„ Sp. Aromat. ℥ii diluted
Antim. Tart. ℥ii
Areca Nux ℥i–ii
Arsenic gr. v–x
Belladonna Extr. ℥i
Calomel ℥i
Calc. Chlorinat. ℥ss
Camphor ℥i
Catechu, &c. ℥ss
Chloral Hydrat. ℥ss–℥i
Colchici Rad. ℥i–℥ii
Cretæ, ℥i ℥ii
Crotonisol. ♏xxx
Digital. fol. pulv. ℥ss
Ergot. Ext. liq. ℥ss
Etheris Spir. ℥i
„ Sp. Nitrosi ℥iss
Filicis Extr. liq. ℥iss
Ferri Carb. ℥ii
„ Sulphas ℥ii
Gentianæ Rad. ℥ss
Iodine gr. xx
Ipecac. pulv. gr. xx–℥i
Magnes. Carb. ℥ss
„ Oxid. ℥ss
„ Sulphas 1lb.
Opium pulv. ℥i
„ Tinct. ℥i
Phenol. gr. v (Carbolic Acid)
External use 1 in 40
Potass. Carb. ℥ii–iv
„ Bicarb. ℥ii–iv
„ Chlorat. ℥ii.–iv
„ Iodid. ℥i
„ Nitr. ℥iv
Quin. Sulph. gr. xx–xxx
Sodæ Carb.–Bicarb. ℥ii–℥iv
„ Sulphas 1lb.
„ Sulphis & hypos. ℥ss–ii
Spiritus Vini (proof) ℥iv
Spirits (Gin, Whisky) ℥iv–x
Strychninæ gr. ii &c.
Turpentine Oil, ℥i ii
Zinzib. pulv. ℥ii
Ung. &c. as in human medicine

Sublimate (Hyd. Perchlor.) solution for the disinfection of walls, &c., one part in a thousand, is made by dissolving 80 grains, with the same of common salt, in a gallon of water. A wooden bucket must be used, since it would corrode a metal pail into holes.

CHAPTER V

LEGAL ASPECTS OF DISEASE IN CATTLE

OUTBREAKS of contagious diseases, epizootics as they are called, by analogy with the epidemic diseases of man, are now, thanks to the enforcement of laws enacted for their prevention and suppression, of such comparatively rare occurrence, that ignorance of the law might easily lead to an unintentional violation of its provisions, or resentment at the apparently high-handed intervention of the authorities.

A large portion of the **Diseases of Animals Act, 1894**, consolidating and amending the previous Acts which were thereby repealed, deals with the importation of foreign cattle, with a view to preventing the introduction of diseases from other countries. Besides the clauses regulating the sale of cattle in markets, their transport by rail and road, &c., there are some regulating the action to be taken by the owner as well as by the authority in the event of certain diseases appearing in any place.

In the case of cattle plague the acting authority is the Board of Agriculture itself, the prompt suppression of so contagious and fatal a disease being deemed a matter of national rather than of local concern; whereas in outbreaks of pleuro-pneumonia and foot and mouth disease the responsibility devolves on the local authorities, though they must notify the occurrence and their action thereon to the Board as the supervising authority.

The principle governing the rate of compensation is that it shall be the higher the less the apparent necessity for the slaughter of the animal. Thus the State is under no moral

obligation to compensate an owner for the compulsory slaughter of an animal attacked with the inevitably fatal cattle plague, and does so chiefly in order to control the destruction of the carcase, and prevent the surreptitious disposal of the same; whereas the slaughter of those affected with foot and mouth disease, from which, after two or at most three weeks, they would almost certainly recover, is carried out in the interest, not of the particular owner who would be very unlikely to slaughter them for so slight a cause, or if he did, would very likely send the carcase to the market, but of the community, with a view to averting the losses, individually small but collectively enormous, incident to a widespread epizootic of that disease. Its compulsory notification to the local authority, which at once takes the establishment in charge, precludes the continued sale of the milk of infected animals, which, though unaffected in quantity or appearance, is capable of communicating the disease, with all its characters unchanged, to persons drinking it unboiled.

The marketable value of the carcases is also taken into account. The flesh of an animal actually suffering from cattle plague would be repulsive to sight and smell, and it would be hazardous to expose for sale any part of the ribs and chest in pleuro-pneumonia, however skilfully dressed; whereas in foot and mouth disease the head and hoofs only, together with the lungs, all coming under the designation of "offal," need be sacrificed; and the carcases of such as had been merely exposed to infection, but in whom the disease, even cattle plague itself, was already incubating, might be bought and sold in the meat market without arousing the smallest suspicion, though such meat could not but be more or less unwholesome.

Every part of the carcase of an animal dying of or killed while suffering from cattle plague or anthrax should be buried or destroyed. Indeed, such is the vitality of the bacilli of anthrax that the blood spilled on the ground, and

even the earth casts discharged on the surface by worms that have fed on the buried carcase, will communicate the disease to others grazing on the spot. Such carcases should be buried as deep as possible, on land not pastured, with the hide uninjured, smothered in quick lime, and drenched with carbolic acid. The communicability of anthrax to man by any abrasion of the skin must also be borne in mind in handling the animals or their carcases.

In the case of pleuro-pneumonia and of foot and mouth disease, the condemning authority reserves the right of disposing of so much of the carcase as it safely can in the way it thinks best. No objection exists to the utilisation of the hide, hoofs, and bones, or the fat for boiling down into tallow or soap, and the flesh for conversion into chemical manures, though that of animals suspected or exposed only to infection might well be used after boiling for the food of hounds.

Diseases of Animals Act, 1894

Abstract of Selected Clauses—Being those affecting the Dairy Farm.

Sec. 4. (1) Every person suspecting that he has a diseased animal shall (*a*) isolate it, and (*b*) inform a police constable, who (2) shall report to such person as the Board of Agriculture may direct.

Sec. 5. A Sanitary Inspector, learning the existence of cattle plague in a place at any time within ten days, shall forthwith (1) make and sign a declaration thereof, (2) serve a notice of the same on the occupier of the premises, and (3) subject to the determination of the Board of Agriculture declare the same to be an infected place. Also (4) unless he deem it inexpedient, on all occupiers of property within one mile, (5) declaring such to be an infected area. (6) He shall forthwith inform the Board of Agriculture, sending copies of his declaration and notices, and (7) the Board shall after local inquiry (8) confirm or (9) amend or annul the declaration.

Sec. 6. The Board may on sufficient information and inquiry declare any place to be an infected place or area, and may alter the limits, or declare it free.

Sec. 8. On learning of the existence of pleuro-pneumonia within 56 days, or of foot and mouth disease within 10, the Sanitary Inspector of the Local Authority shall (1) forthwith make and sign a declaration thereof, (2) serving notice on the occupier of the premises which (3) shall, subject to the determination of the Local Authority, be deemed an infected place. (4) He shall forthwith inform the Local Authority, sending copies of the declaration and notice. (5) The Local Authority shall then, with the advice of their Veterinary Inspector [or any legally qualified veterinary surgeon, *i.e.*, M.R.C.V.S.,] and after inquiry either (6) confirm his declaration, including if they think fit any adjacent land or premises within their district, and (7), with the consent of the respective authorities, in those of others also, or (8) may declare which places have become free. (9) The Local Authority shall forthwith report to the Board of Agriculture the declaration of their Sanitary Inspector and their action thereon, (*a*) what places or areas have been declared infected, and, (*b*) if there be any markets therein, whether they should or should not be prohibited by Order in Council. (10) This section shall have like effect when the animals are not in the possession or control of the owner.

(11) Not less than 56 days after the declaration of pleuro-pneumonia, and not less than 14 nor more than 28 days after that of foot and mouth disease, the Local Authority may, with the consent of the Veterinary Inspector, declare the place free.

[The meaning of this is that, always supposing the disease to have ceased, no new cases having appeared within the periods named, the withdrawal of the embargo on the place *must not* be entertained within 56 days of the last notification of pleuro-pneumonia or 14 of that of foot and mouth disease; but that while this *may be* indefinitely deferred in

the case of pleuro-pneumonia, its expediency *must* be considered in that of foot and mouth disease when a month has elapsed.]

Sec. 11. Prohibits the movement of cattle into, out of, or within an infected place or area.

Sec. 13. Owners of infected animals may post notices excluding strangers, *i.e.*, "persons not having by law right of entry," from their premises.

The Following Sections regulate the Slaughter and Compensation.

Sec. 7. The Board of Agriculture (1) shall cause to be slaughtered (*a*) all animals affected with cattle plague, or (*b*) such as have been exposed to infection and (*c*) any such also as are suspected or have been in an infected area though not in an infected place, (3) paying as compensation half the original value of the affected, and the full value of the suspected, such payments, however, not to exceed the sums of £20 and £40 respectively for each animal.

Sec. 14. (1) The Board *shall* cause all animals affected with pleuro-pneumonia to be slaughtered, and (2) *may* also (*a*) suspected animals, and (*b*) those that have been exposed to infection, (3) giving as compensation for (*a*) the affected three-quarters of their previous value, and (*b*) the full value of the others; the payments not to exceed £30 and £40 respectively. (4) The owner may require of the Board the slaughter of animals exposed to infection within twenty-one days.

Sec. 15. (1) The Board *may* cause the slaughter of animals (*a*) affected with or (*b*) exposed to foot and mouth disease, (2) compensating the owners to their full value before illness or slaughter.

Secs. 18 and 19. The Board may extend the provisions of this Act as regards slaughter and compensation to other diseases and to other animals than those mentioned in the Schedules.

Sec. 20. (1) The Board may on paying compensation remove any animal liable to be slaughtered, for the purpose of treatment or observation. [This is to enable their scientific officials to carry out investigations and experiments on the nature, treatment or prevention of the diseases, especially in respect of their bacteriology and of preventive inoculations.] (2) The carcases of all animals slaughtered by order of the Board or of the Local Authority shall become the property of the respective authorities, and be buried, destroyed, or disposed of by them in such manner as they shall think fit; (3) but any excess of the proceeds over the sum paid for compensation shall be returned to the owner. (5) In the case of insured animals, insurers may deduct amount of compensation. (7) Compensation may be refused wholly or in part if the owner have violated any provision of the Act.

Sec. 22. The Board of Agriculture may make orders on any and every matter bearing on the execution and intentions of the Act.

Sec. 57. The *onus probandi* (1) of ignorance of the existence of diseased animals in his possession, or (2) of having properly cleansed and disinfected the premises, or (3) of the non-commission of any offence or neglect rests with the accused, who (4) may demand to be examined and may give evidence on his own behalf, and (5) a part not exceeding half of the fine may at the discretion of the Court be paid to the informer or prosecutor.

Dairies, Cow-sheds, and Milk Shops Order, 1885.

The Diseases of Animals Act, like the previous Contagious Diseases (Animals) Acts, which it consolidated and repealed, both in the sections of which abstracts have been given above, and in those regulating the importation of foreign cattle, is aimed at preventing the introduction from abroad and of repressing the first outbreaks at home of certain highly infectious diseases, which, if they once got the upper hand

and assumed the proportions of epizootics, would involve an enormous mortality of cattle and ruinous pecuniary loss to the country generally; and lastly, at all times at the prevention of suffering by animals in course of transit by rail, &c.

Its provisions are capable of unlimited extension, though as yet dealing specifically with cattle plague, pleuro-pneumonia, and foot and mouth disease only, so far as the cow-keeper is concerned, and with swine fever.

The definitions of "animals" and of "disease" may be extended at the discretion of the Board of Agriculture, but there seems no disposition on their part to include any disease, however dangerous to the health of the community, that does not immediately affect the pecuniary interests of the owner; and although the contagiousness of tuberculosis among cows, and the infectivity of their milk to infants, have been amply demonstrated, all attempts to have tuberculosis added to the Schedule have as yet been unavailing.

A magistrate may under the Public Health Acts, if satisfied by the evidence of the Medical Officer of Health that the carcase of a tuberculous animal is unfit for human food, order its destruction, but so long as a tuberculous cow is capable of yielding milk, though the implication of the udders may be palpable, and the bacilli in the milk demonstrable, the law takes no cognisance, and only moral suasion can be brought to bear.

The Dairy, Cow-sheds, and Milkshops Order of 1885 is an improvement on those that preceded it, but is marked by one defect which destroys all its value as regards the general hygiene and sanitary conditions of the dairy farm or the urban cow-shed, since it leaves to the local authority the determination of what constitutes *proper* ventilation, cubic space, cleansing, &c., without even compelling them to fix any minimum or standard, with the result that so long as such premises do not, from their position, &c., constitute a nuisance and ground of complaint by the occupiers of neighbouring houses, nothing is done.

Abstract of Clauses of Dairies, Cow-sheds, and Milk Shops Order, 1885.

(The Order extends to England and Wales only.)

Sec. 6. Cow-keepers and dairymen to be registered by the local authority, except such as make butter or cheese only and do not sell milk; and persons selling to their neighbours small quantities of milk from their own cows, not kept for trade. Such registration does not authorise the occupation of any particular premises.

Sec. 7. No person may begin to occupy as a dairy or cow-shed any buildings not so used prior to this Order, unless he provide to the satisfaction of the Local Authority for the lighting, ventilation, air space, cleansing, drainage, and water supply; nor without giving one month's notice of his intention.

Sec. 8. No person shall occupy as a dairy or cow-shed any building, whether so used previously to this Order or not, if and so long as the said conditions "are not such as are necessary and proper for (1) the health of the cattle, (2) the cleanliness of the vessels, and (3) the protection of the milk from infection or contamination."

Sec. 9. No person suffering from any dangerous infectious disease [as defined by the Public Health and Infectious Diseases Notification and Prevention Acts], or having recently been in contact with any person so suffering [this should include proximity or association], shall milk cows, handle vessels, or take any part in the "production, distribution or storage" of milk until all danger of infection is past.

Sec. 10. No water-closet, earth-closet, privy, cesspit or urinal shall be allowed, after one month's notice from the Local Authority, to be in direct communication with or ventilate into any dairy or milk store.

Sec. 11. No dairy or milk shop shall be used as a sleeping-room, or for any purpose incompatible with the purity of the milk.

Sec. 12. No swine shall be kept in any cow-shed.

Sec. 13. The Local Authority *may** from time to time make regulations for (*a*) inspection of cows; (*b*) prescribing and regulating the sanitary arrangements of dairies and cow-sheds; (*c*) securing the cleanliness of milk shops, &c.; and (*d*) precautions against infection.

Sec. 14. Such regulations shall be advertised in the local newspapers, a copy having been one month previously submitted to the Local Government Board for approval.

Sec. 15. Milk from a cow suffering from disease [as defined by the Diseases of Animals Act, which does not include tuberculosis] may not be mixed with other milk, or sold for use for human food in any way, nor may it be given without having been previously boiled, to swine or other animals.

Sec. 17. Nothing in this Order shall be deemed to interfere with the regulations for cattle-sheds in the Burgh (Scotland) Act [or Acts superseding the same].

Dairy, Cow-sheds, and Milk Shops Amending Order, 1886.

Art. 3. Imposes for violation of the Order of 1885 a fine of £5, with a daily penalty of £2, either of which may be reduced by the Court; substitutes Local Government Board for Privy Council, and defines Local Authorities.

Contagious Diseases (Animals) Act, 1878.

Sec. 34. [Not repealed by the Diseases of Animals Act, 1894.] The Privy Council [now the Board of Agriculture] may make, subject to the provisions of the [Diseases of Animals] Act, general or special Orders for all the purposes specified in the Order of 1885.

Desiderata.—The 13th section of the Order of 1885, and the 34th of the Contagious Diseases (Animals) Act

* This use of "may" when it should be "shall" is the weak point in much of our Public Health legislation; local option in matters which must everywhere be for the good of the public is simply sanctioning inaction where action is most urgently called for.

1878, contain great potentialities for usefulness were they not rendered futile by their optional character. The enactment of by-laws and regulations under Section 13 of the Order or by the Board of Agriculture, as the successor to the powers of the Privy Council under the 34th section of the Act of 1878, should be compulsory, as is that of by-laws for municipal sanitation under Section 16 of the Public Health (London) Act, and the local authorities for the purpose should be the County Councils and those of county boroughs only, to the exclusion of the smaller urban and Rural District Councils. Greater uniformity would be thus ensured, unless the regulations were drawn up by the Board of Agriculture for the whole country; and in either case these greater authorities would be able, and should be required, to retain the services of a highly qualified veterinary officer, assisted by one, or, in the case of County Councils, several inspectors. This is already the case in Italy, where the provincial councils, corresponding to our County Councils, appoint a veterinary officer co-ordinate with the provincial medical officer of health, whose duties extend to the supervision of the health and sanitary conditions of all cattle and domestic animals, as those of the medical officer do to the health of the population.

CHAPTER VI

THE ELIMINATION OF TUBERCULOSIS

MANY years ago Koch, who had already discovered the bacillus of tuberculosis, conceived the idea that, as in the case of some other diseases the phenomena of which were caused by poisons secreted by bacteria, antagonistic principles could be obtained from extracts of their bodies, it might be possible to do the same with those of tuberculosis. He thus prepared more than one such substance which, injected into men or animals suffering from tuberculosis, set up a febrile reaction, while they produced no effect whatever in individuals free from the disease. His hopes of thus obtaining a curative agent proved illusory, as might have been expected, when one reflected that tuberculosis is a disease which exhibits no constant tendency to a spontaneous termination within a definite period, but, if not arrested, proceeds, as a rule, in an uninterrupted course to a fatal conclusion. But while tuberculin has failed as a preventive or curative agent, its value as a means of diagnosis has been fully established, and has led to the discovery of an analogous body, mallein, which is equally valuable for the detection of glanders, even before any symptoms of the disease can be recognised.

Though the cow, naturally, is very undemonstrative, showing no signs of suffering or ill-health, even when in advanced stages of chronic disease, an injection of tuberculin sets up in an animal in all but the very earliest stage of tuberculosis, and in whom no symptoms whatever are to be detected, a febrile disturbance, lasting several days, and exhibiting a temperature curve quite characteristic to the eye of the

trained observer, while in an animal entirely free from any trace of the disease no reaction follows even large and repeated injections.

Professor Bang, of Copenhagen, has applied this procedure, carried out systematically, to the elimination of tuberculous animals from a herd. His method is to inject the whole of the cows, and to separate those that react from the others. This separation must be complete, the animals being housed as far as possible from one another, and with different attendants, the sheds devoted to the healthy cows having been thoroughly cleansed and disinfected.

Those that have reacted are then fattened for the butcher, though they may, if showing no other evidence of the disease, be allowed to calve once, provided the calf, which is always, except in very rare instances of advanced maternal disease, born healthy, be removed immediately, and before it has been suckled by its mother, to the establishment of sound cattle. These and the calves are injected at intervals of six months, and any that react from having been by any means infected subsequently, or in whom on the previous occasion the disease was in so early a stage as to cause no reaction, are removed and fattened, as were the others. All newly-purchased animals are tested and sent to one or other of the establishments, according as they react or not, and the operation is repeated on them six months later if the first result was negative. In the course of eighteen months or two years, if the separation of the herds have been complete, no more cases of reaction will be met with, and the affected animals will have all been disposed of. If the treatment has been conscientiously carried out the herd will be, and will remain, free from the disease, provided only any additions thereto by purchase be kept apart until they have been twice tested, viz., on arrival, and at the expiration of three to six months. This course has been adopted by many owners of dairy farms in Denmark and elsewhere, as well as by a few in this country.

Such a certificate of absolute freedom from tuberculosis granted by the Board of Agriculture should constitute a recommendation of the highest commercial value; and private individuals who often keep Jersey cows by preference ought certainly to avail themselves of the opportunity of once for all eliminating tuberculosis from their stock, since these are the most susceptible of all to this disease, the great majority being attacked sooner or later.

No pains should be spared on the disinfection of the sheds, mangers, &c., set apart for the tested animals, and no newcomer should be admitted until she has shown herself refractory to the first inoculation. The newly-purchased cow must be kept in sight in quarantine meanwhile, but on no account associated with the tuberculous cows, if any remain, since, until the contrary be proved, she may be assumed to be free from disease.

The importance of disinfection rests on the fact that by far the most frequent means by which healthy cows become infected is through the bespattering of the walls, troughs and fodder with the nasal discharge and expectoration of those already tuberculous. No cow suffering from a cough should be allowed to associate with others, still less should they ever occupy a stall or standing after her.

CHAPTER VII

INSPECTION AND CONTROL OF COW-SHEDS

THE control of milk adulteration, at any rate in the larger towns, by the systematic seizure of samples for analysis, is on the whole fairly effective; the law being fully adequate for the purpose in view, if only the seizures were more frequent in those quarters in which dilution and sophistication are most likely to be practised, that the chances of escape might be lessened; and if the fines imposed were such as not merely to reduce the illicit gains, which is the most they usually achieve, but to transform a lucrative business into a ruinous one.

Thus, for instance, a retailer who had been selling 300 quarts of milk at 4*d.* a quart, turning over £5 daily, and making a profit of say £1, would, by substituting 15 quarts of water for as many of milk, equal to five per cent. dilution, the water costing him nothing, add 5*s.* daily to his profits, in place of the 1*s.* that he would have made on the superseded 15 quarts of milk, by a fraud which, if the milk happened to be originally of high quality, the analyst might find it difficult to prove to the satisfaction of an unscientific magistrate. If this practice had been carried on for eight or nine months without detection he would have netted a clear profit of £50; and the absurdity of imposing a fine of 50*s.*, or what is more likely 20*s.*, "taking into consideration the small percentage of added water, and the fact of its being a first *offence*" (rather a first conviction), is evident. Such trivial penalties can exert no deterrent influence over men whose dealings are

mainly with the unthinking and migratory poor, or with street hawkers. But after all the analyst can decide on the questions of dilution and adulteration only; he can form no opinion as to the sanitary conditions of the cow-sheds, the health of the animals, and the fact or the risk of the milk being a vehicle of infection with human diseases.

Nor can the ordinary Sanitary Inspector, whose technical education, if he have had any, has been at best that of a plumber or general builder, form a sound judgment on the sanitary conditions of a dairy farm. Such antecedents indeed supply a good basis on which to begin a study of house sanitation, drainage and sewerage, but insufficient in themselves for one whose duty is the observation of conditions of health and disease, though it would not be impracticable for the County Councils to obtain the services of intelligent young men of that class who might by special training acquire real aptitude for the work.

What, however, is really wanted is that, following the example of the Boards of Health of the "provinces" of Italy, which closely correspond with our administrative counties in their area, population, and local government, our County Councils should appoint a Veterinary Officer, co-ordinate with the County Medical Officer of Health, whose duty it would be to control the sanitary conditions under which all kinds of animals are kept; to note the occurrence and to direct the measures taken for preventing the spread of contagious diseases among them, and generally to exercise in respect of cattle and domestic animals the like functions that the Medical Officer of Health does in respect of the human population.

At present, however, the County Councils have the power to issue regulations as to the construction and arrangements of cow-sheds, the cubic space to be allowed for each animal, to inquire as to the prevalence of tuberculosis, and otherwise to control the sanitary conditions of dairy farms,

though, except in a few of the southern counties of Scotland, these powers have been almost wholly in abeyance.

Some towns have local Acts, as Croydon, where by an Act of 1900 the authority is empowered to impose penalties on any person selling milk from a cow with tuberculous udders, keeping such cow along with others, or failing to give notice when any cow in his possession is proved or suspected to be thus affected; to take samples of milk for examination; to inspect cows within or without the borough, and under certain circumstances to prohibit particular dairymen from supplying milk within the borough. Article 15 of the Dairies, Cow-sheds, and Milk Shops Order, 1885, provides that the milk from "diseased" cows shall not be mixed with other milk used for human consumption, or, unless boiled, for the food of swine or other animals, but limits the definition of disease to cattle plague, pleuro-pneumonia, foot and mouth disease, and "such *disease of the udder* as shall be certified by a veterinary surgeon to be tubercular." This last provision, added by the Amending Order of 1899, is unsatisfactory, for there can be no doubt that milk containing pus and teeming with the bacteria of suppuration, or with those proceeding from vesicular diseases of the udder, is unfit for the food of man, and that its sale should be prohibited equally with that of cows suffering from tubercle of the udder, nor does it provide for the compulsory notification of every case of disease of the udder in milch cows, so that actual tubercular disease may escape detection by the simple device of professed ignorance of its nature on the part of the cowkeeper, and his consequent neglect to seek the opinion of a veterinary surgeon.

If all cows were subject to periodical inspection by a veterinary surgeon, appointed or permanently retained by the County Council or the Local Authorities, and these bodies respectively were granted concurrent powers, there would be no occasion for the invidious intrusion of one Local Authority into the district of another, which is necessary for

their own protection, when one only, as in the case of Croydon, has any such powers. Practically the prevalence of tuberculosis is directly as the time passed by the cows "indoors," and thus in the case of the more tender breeds, especially the Jerseys, which must be housed through a great part of the year, and in town dairy farms, where the same confined existence is necessitated by circumstances, tuberculosis can be eradicated from a herd by nothing short of a strict carrying out of Prof. Bang's method. But among the hardier kinds, Shorthorns, Ayrshires, Kerrys, &c., the prompt removal of individual cows showing "clinical" evidence of disease will mostly be sufficient, provided that, along with good feeding and cleanliness, and the simple contrivance in connection with the feeding-troughs described on pp. 33 and 34, they are accustomed, so far as possible, to an open-air life. With closed sheds or cow-houses the question of cubic space assumes a high degree of importance; but cubic space, however ample, is of no avail without adequate provision for ventilation. All, however, that the hardier breeds really need, if well fed, is shelter from rain, snow and cold winds, which is fully provided by open sheds, that is sheds open on one side throughout their whole length, clean, dry, and well drained, and protected from cold winds by another line of sheds or other buildings parallel with but at some distance from the open side, as is the case in a rectangular yard.

With regard to the spread of human disease through the agency of milk as a vehicle, the existing law would be fairly effective if only it were amended in a few directions. Now that the Infectious Diseases (Notification) Act is no longer optional, the occurrence of cases of scarlatina, diphtheria, or typhoid fever among persons connected with a farm or dairy, or among those consuming the milk sent out therefrom, is everywhere brought under the cognisance of the Local Authorities; and the Infectious Diseases (Prevention) Act, the provisions of which are incorporated into the London Public Health Act, would be sufficient for the purpose of preventing

their further spread, were they not to a great extent stultified by conditions, the perverse ingenuity of which is nothing less than astounding.

The clause in question (sec. 4 of the Infectious Diseases (Prevention) Act and sec. 71 of the Public Health (London) Act), stripped of superfluous verbiage, is that if the Medical Officer of Health finds that any person *in his district* is suffering from dangerous infectious disease attributable to milk from a dairy *in or out of his district*, or that the milk from one dairy *is likely to cause* such disease to persons *in his district*, he shall obtain an order from a justice of the peace in the district where the dairy is situate to inspect it, and, if accompanied by a legally qualified veterinary surgeon, to inspect the animals, and if satisfied that the consumption of milk therefrom is the cause of such disease, he shall report to the Sanitary Authority, appending the report of the veterinary surgeon; and the Sanitary Authority *may* serve on the keeper of the dairy notice to appear before them, within not less than twenty-four hours, to show cause why an order should not be made on him not to supply milk WITHIN THE DISTRICT until the order is withdrawn. The remainder of the section is concerned with details of legal procedure, &c.

Two grave defects in this clause are (1) that the Medical Officer of Health must, after inspecting the dairy, prove that disease has been actually caused by the milk sent out, thus neglecting the *prevention* of disease, recognised in the new phrase, "injurious or *dangerous* to health," and in the title of the Act itself, so that he cannot close a dairy though cases of scarlatina or diphtheria were found on the premises, until the disease has already extended to the customers, and probably an epidemic has been set up. It is in London only that by sec. 69 of the Public Health Act of 1891 a person "knowing himself to be suffering from a dangerous infectious disease" can be precluded from milking cows, or handling milk or other food; and

(2) that *the sale of the condemned milk is permitted anywhere*

except in the particular district. Milk conclusively shown to have spread disease in one district may and will be freely sold in another, and will in most cases be sent to London.

The first defect is probably an inadvertence, and the words "likely to be caused" might be read in from a previous sentence, but the second is incapable of extenuation. The words "within the district" should be omitted, being a good illustration of the much misunderstood maxim of the Roman law, that "the exception proves the rule"; the prohibition of the sale *within the district* clearly implying permission of its sale out of the same. What could be more futile and absurd than to forbid the sale of infected milk where the circumstances are well known, and it would probably be an easy matter to persuade every one to take the precaution of boiling all milk, and to permit its sale in places where entire ignorance of its place of origin exists, and hence no suspicion will be entertained of the danger.

There is always at the railway termini in London, and probably at those in the great provincial cities as Birmingham, Manchester and Liverpool, a quantity of what is known as "accommodation milk," that is, milk not consigned to regular contractors, but sent up in the expectation of its being taken by casual customers. The larger vendors have recourse to this to meet any unexpected deficiency or unusual demand, and many of the smaller retailers depend solely on it for their supply, buying their daily quantity in the open market. How much of "accommodation milk" consists of milk condemned in its place of origin, and as a result how many local outbreaks of infectious disease in the poorer parts of the metropolis, the cause of which baffles inquiry, might be traced to these sales if the source of the milk were known, it is impossible to estimate.

The Public Health (Scotland) Act, 1897, Sec. 58, is much more explicit than the corresponding section of the London Act (sec. 69) as to infected persons, *or persons residing in infected houses*, milking cows or handling food.

Sec. 60 empowers the Medical Officer of Health to inspect dairies *at any time*, and the Local Authority to prohibit the sale of milk that is likely to be a vehicle of disease, *absolutely* (subject, however, to appeal to the Sheriff), and not, as in the English Acts, only when disease has been already spread, and then within the district only.

Sec. 61 enables the Local Authority to require production of lists of customers of a suspected dairy.

When outbreaks of scarlatina or diphtheria have been proved to have been connected with a particular milk-supply, it has always been found that persons, either themselves suffering from the disease or in attendance on or contact with others so suffering, have been engaged in milking cows or handling the milk in the dairy or the shop. But when typhoid fever has been no less conclusively traced to a milk-supply the link has been very rarely so directly personal, the source or means of infection of the milk having been the use of water contaminated with the evacuations of a typhoid patient, for diluting the milk, or in the washing of the churns and other vessels.

In large dairies employing steam power for other purposes, the cleansing of all utensils is effected by means of steam; in others and in well-conducted farm dairies boiling water from a copper is used; but too often even this precaution is neglected, and cold water from the nearest pump, or it may be stream or pond, is considered good enough for the purpose.

The frequent juxtaposition or close proximity of the cesspit and the well, the former pervious and draining into the ground water into which the latter is sunk, renders the contamination of the supply inevitable when the evacuations of a typhoid patient are emptied into the cesspit. An inspection of the water-supply of all dairy farms should be made by the local authority, and whenever this is found to be exposed to the risk of pollution another should be found, or the source of possible pollution removed by the substitution

of earth closets for the old-fashioned privy. These precautions for securing the purity of the water-supply on farms, whether for the use of the refrigerator or for cleansing the churns and pails, are insisted on by the medical officers or inspectors in the employment of all or most of the great dairy companies; but on those farms which are under no such control, and the milk from which is distributed directly in the neighbourhood, sent to small retailers, or sold in the open market, the sanitary conditions are often most unsatisfactory in every respect, and will continue to be so until the local authorities awake to a sense of their responsibility, and avail themselves of their powers to enforce by-laws on these matters.

Dirty milk.—If milk be gently poured from a vessel, especially one of white porcelain in which it has stood for an hour or so, a black gritty sediment will mostly be found. Some of this consists of coal and other mineral dust, that has found its way into the churns in course of transit by rail and road, and is consequently inert and so to say clean; but much of it can be shown by the microscope to be simply cow dung, which has been literally washed in the process of milking from the flanks and udders of the cows, and the hands of the milkers, and has passed through the meshes of the coarse muslin through which the milk is strained, and which is intended only to intercept hairs, insects and the like. Apart from its intrinsically disgusting character, it is the chief, if not the sole vehicle for the introduction of the *Bacillus coli*, which is the main agent in the souring and putrefactive changes that set in with a rapidity and intensity proportional to the want of cleanliness in the milking operations. This putrescent souring is a totally different process from the natural souring produced by the lactic acid ferment that occurs at a later period, and is seen in the souring of cream, and the preparation of cream cheeses and the German "sauer Milch" for which the cleanest milk only can be used; it, on the contrary, is the

cause of "turning" within twenty-four hours, and of the coagulation that takes place in some milks when boiled while still apparently fresh.

The fæcal matters may be removed by the use of finer muslin or linen strainers, and even without such treatment they will, sinking to the bottom of the vessel, leave the bulk of the milk entirely free from visible dirt; but neither straining nor subsidence can have any effect on the number of bacilli which are diffused throughout the whole mass of the liquid; and the putrescence and the formation of bacterial products will proceed equally with or without the gross matter in which the bacilli were contained. Such milk is always more or less unwholesome, and may to infants be actually and actively poisonous, giving rise to vomiting, diarrhœa, and grave gastro-intestinal disturbances.

CHAPTER VIII

THE PHYSIOLOGY OF MILK

THE constituents of milk, the fats and sugar equally with the proteids, are all formed from the protoplasmic contents of the cells of the epithelium lining the ultimate ramifications of the ducts of the mammary gland, through the vital activity of the cell itself. This is a matter of the utmost practical, as well as scientific, importance, in its bearing on the question of food, since it would naturally be assumed that a diet rich in fat would tend to increase the proportion of this the most variable of the constituents of milk, whereas the reverse is the case.

The only living matter, protoplasm, "the physical basis of life," as Prof. Huxley described it, is a vitalised proteid, and needs proteids for its pabulum in the animal body, but in the plant it is capable of maintaining and constructing itself out of its ultimate and inorganic materials.

All fats, ingested as food, and taken up by the lacteal vessels of the intestine, are broken up, burnt as fuel in the system, and so utilised in the production of energy and heat. Any excess above what can be absorbed passes away unchanged in the fæces, none being stored up in the organism. All the fat deposited in the tissues or excreted as in milk is formed afresh in the body, and from albuminous matters as the raw material, together with urea as a by-product, and is not derived from the "working up" of the fats ready to hand in the food. Since the oxidation, combustion, or, as it is best called, the metabolism of fatty and starchy, *i.e.*, the non-nitrogenous, bodies is far easier all

simpler than that of the nitrogenous proteids, they afford the better fuel, and are always utilised first, leaving so much of the albumens as is not required for the repair of the tissues to be stored up as fat. But while metabolism generally is stimulated to greater activity by an excess of nitrogenous food-stuffs, it is retarded by an excess of non-nitrogenous, especially fatty foods, whence it follows that an excessive proportion of these tends rather to lower the percentage of fat in the milk, the materials whence this is derived being provided by the albuminoids, and the function of the fats and carbohydrates is, so far as possible, to spare these from waste by providing energy and heat. A cow at grass, not to speak of animals the subjects of physiological experiments, yields in her milk considerably more fat than she takes in with her food The sugar, too, is formed from the same protoplasm and not from the carbohydrates absorbed with the food, since a carnivorous animal or a dog will give a milk containing the normal amount of sugar, though there may be absolutely no carbohydrates in its food.

The milk of all mammalia consists of water holding ten to fourteen parts per thousand of solids, salts and sugar in crystalloid, and albumen in colloid solution ; casein in a state that has been called pseudo-solution—*i.e.*, in particles large enough to intercept the rays of light, and to give a white opacity to the fluid, and to be arrested by a fine filter as Pasteur's, but so small as to be uninfluenced by gravitation or attraction, and to remain uniformly diffused ; and fat in suspension, the globules from 0.1 to 0.001 mm. diameter, tending in virtue of their lower specific gravity 0 9 to rise to the surface, though so long as they are intact the supernatant layer of cream contains a large admixture of the water and the solids in various states of solution. The proportions absolute and relative of these several constituents, especially those of the fat, vary, but within narrow limits, so that the composition of the milk is fairly constant for the species, the race or

breed and the individual; this is strictly true of the casein and sugar, but less so of the fat, which is greatly influenced by the food, the period of lactation, and the age of the animal. Casein is an albuminous body, but distinguished from the albumens strictly so-called by several characters. Thus, although coagulated by acids and pepsin, it is not coagulated by heat, while the casein of one species of animal differs from that of others in its physical characters, especially the density of the curd.

Ignoring those of the carnivora and rodents, with which we are not concerned, milks fall under two or three types, viz., (1) the ruminants, (2) the human and asinine, and (3) the equine. The first is distinguished by the high percentage of casein and the density of its coagulum, the percentage of sugar being at the same time low; and the second by the lower percentage of the casein, while that of the sugar is high, and the soft flocculent consistence of its curd. Human milk and that of asses, though practically identical in the percentages of casein and sugar, and in the character of the curd, differ in the amount of fat which in the former is nearly as great as it is in cow's milk, but in the latter is very low. The milk of the mare presents a low percentage of casein and fat, while as regards sugar it is intermediate between the other types, except in the case of the mares of the Steppes, whose percentage of sugar is lower than in any other variety, while that of the casein is nearly as high as it is in the milk of the cow. The salts are highest in the milk of ruminants, and lowest in that of the human female; but for some unknown cause mare's milk possesses a laxative action on the bowels. Besides the casein all milks contain a certain proportion of an albumen almost identical with that in blood serum, and like it coagulated by heat. Considerable uncertainty attaches to the exact amount of this albumen in human milk, owing to the difficulty of separating it from the very soft coagulum of the special form of casein; indeed, while the majority of analysts give the percentages of casein

and albumen as 1.0 and 0.7, Hauser gives the inverse proportions of 0.77 and 1.59.

The following may, however, be accepted as averages from the best analyses:

Animal	Water	Casein	Albumen	Fat	Sugar	Salts.
Cow	87.0	3.3	0.4	3.8	4.8	0.7
Goat	87.5	3.00	0 7	4.2	4.0	0.6
Goat (other analyses)	86 0	3.5	0 9	4 6	4.3	0.7
Woman	88 0	1 0	0.7	3.3	6.8	0.2
Ass	90.0	0 9	0.6	1.2	6 8	0.5
Mare.						
Konig[1]	90 7	1.25	0.7	1 17	5 7	0.37
Vieth[2]	90.0	1.9		1.1	6.7	0.3
Fleischmann-Seeland[3]	91.0	2.0		1.0	5.6	0.4
	91.42	2 93		1 8	3.6	0.22

[1] *Chem. Zusammensetzung der Mensch. Nahrungs und Genussmittel.* 1879.

[2] Average mixed milk of Steppe mares at Internat. Health Exhib. London, 1884.

[3] Taken on the Steppes at Szamara.

Some persons have claimed for goat's milk a peculiar fitness for infant feeding, but on what grounds it is hard to say. The percentage of fat is greater, and that of sugar less, than in cow's milk, removing it still farther in composition from that of the human female, while the casein presents the same hard indigestible coagulum as does that of the cow, and the milk presents in a marked degree the rank smell of the animal, rendering it repulsive to adults, at any rate in Western countries. In the old days of long voyages in sailing-vessels, when condensed milk was unknown, it was a frequent practice to carry milch goats for the use of children returning from India; goats standing rough weather better, and having less need for green food than cows, and it being much easier to keep their pens clean. The practice might still be adopted with advantage in the case of infants with whom condensed milk was found not to agree.

To give, as some writers have given, the composition of the

milk of the hippopotamus and the porpoise would be useless and pedantic; but there are two milks, those of the sheep and the buffalo, which, though never used in Europe, are in some Eastern countries almost the sole kinds to be obtained, and unfortunately with disastrous results in the artificial feeding of infants, as in recent Indian famines, when over wide areas no cow's milk could be had, save by importing the animals from distant regions, none but buffaloes being used for milch or draught purposes. Both these milks are remarkable for the high percentage of solids, especially of the fat, and that of the ewe of albuminoids also.

	Water.	Fat.	Sugar.	Casein	Alb.	Salts.
Sheep	79.46	8.63	4.28	5.28	1.45	0.97
Buffalo	78.63	7.61	4.52	3.54	0.60	0.90

Buffalo's milk is much used in India and in some parts of Africa, but it is from its indigestibility utterly unfit for infants. Sheep's milk, though still drunk to some extent in Syria, is in Europe employed solely in the manufacture of the Roquefort and one or two other local kinds of cheese, for which its high percentages of casein and fat render it well adapted.

The composition of milk depends mainly on the breed and the stock, that is on hereditary characters, but it varies also in the individual cow with her age and the period that has elapsed since the birth of the calf, and is also influenced by the quantity and quality of the food, the so-called seasonal and diurnal variations being when examined wholly explicable in this way:

Seasonal.—*November to January*, the milk is at its best, rich in fat and solids other than fat.

February to April, the fat is less, though the other solids remain stationary.

May to August, the fat remains low, though towards the end of this period there may be some tendency towards a

rise, while the solids not fat continue to fall throughout, the milk being poorest in every respect in July and August.

September and October, during these months the quality of the milk as regards both the fat and the other solids improves until the high standard of the winter product is reached.

Daily Variations.—The lower percentage of fat in Monday milk is owing to the accidental circumstance of both the feeding and the milking being apt to be neglected on Sunday; but it is a matter of common observation that the morning's milk is richer in fat than that drawn in the evening. The difference is less when the intervals are equal, twelve hours between each, than it is when nine or ten intervene between the morning and evening milkings, and fourteen or fifteen between those of the evening and morning.

Partial Milk.—The necessity for the thorough mixing of the whole quantity taken at a single milking, whether for sale or sampling, rests on the remarkable fact that if it be drawn in successive portions the percentage of fat will be found to rise steadily from the first to the last. Boussingault gives the following analyses of milk drawn in six successive portions:

Portion.	1	2	3	4	5	6
	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.	Per cent.
Total solids .	10.47	10.75	10.85	11.23	11.63	12.67
Fat . . .	1.70	1.76	2.10	2.54	3.14	4 08
Solids not fat .	8.77	8.99	8.75	8.69	8.49	8.59

It will be noticed that the variation is really in the fat only, that in the other solids being trifling, if not apparent only and secondary to the former.

The influence of the food on the milk is very marked, but of so complex a character that, though amenable to empirical rules, it is not capable of any exact scientific explanation. The constituents of the milk consist of the three food-stuffs,

albumens, fat, and carbohydrates, and are of course ultimately derived from the food, but not, as might have been supposed, the fat from the fat, and the sugar from the carbohydrates. No addition of fat to the food, however otherwise beneficial, increases the fat in the milk, which is in fact, equally with the casein and probably the sugar, derived from the albuminates; it is the high percentage of these in cake that gives it its value, the accompanying fat providing heat and energy, and leaving the whole of the albumen available for producing casein, fat, &c., in the milk. The first portion drawn is called the foremilk and the last the strippings. In the former Heaton once found no more than 0.26 per cent. of fat, while over 10 per cent. is not unusual in the latter, which are sometimes sold as cream. The foremilk drawn in the presence of the magistrate has often in days past been offered for analysis for the purpose of rebutting a charge of adulteration, as being probably poorer than the watered milk, on the analysis of which a conviction had been applied for or granted. This, however, can no longer be done.

Another variation occurring in the same mass of milk is that of the gradual ascent of the fat globules preparatory to the rising of the cream, and the effect of which on the deeper portions in cylindrical "churns," whether the usual 12-gallon used for transporting milk or the smaller 12-quarts kept on the counters in shops and restaurants, is perceptible in a quarter and serious in half an hour, the percentage of the fat in successive portions, drawn at intervals of fifteen or twenty minutes from taps at the bottom of such vessels *at rest*, sinking in a number of observations from 3.7 to 2.5 in the course of a little over two hours.

Colostrum, *vullo* "*beestings*," is the name given to the secretion of the mammary glands prior to and shortly after the act of parturition. It differs from normal milk in several respects, both chemical and physical, which disappear in the course of four or five days from the calving,

during which the milk should be used only by the calf itself.

For some time, however, the percentage of fat is low, it and that of the casein increasing, while that of the sugar diminishes, during the period of lactation, being nature's adaptation to the wants of the growing calf.

Taking mixed breeds of cows as found on English farms in the Southern and Midland counties the average composition of the milk from 200,000 analyses made by Dr. Vieth and Troop Richmond in the laboratory of the Aylesbury Dairy Company is :

Water	87.10	Casein	3 00
Fat	3 90	Albumin	0.40
Sugar	4 73	Ash	0.75

	Fat.	Solids not fat.
Maximum	12.52	10.60 (Bannister)
Minimum	1.04	4.90 (Vieth and Richmond)

Some abnormal milks observed by Dr. Vieth gave :

	Water	Fat	Solids not fat	Sugar	Proteids.
1	89.00	4.90	6 10	1.91	3.35
2	85.20	7 80	6 60	2 13	3 32
3	85 30	9.40	4.90	—	—
4	83.30	10.5	6.20	—	—
5	86 14	3 62	10.24	4.66	4 58

Apart from these abnormal cases the ratio between the milk sugar, proteids and ash given by Vieth as 13 : 9 : 2 is almost constant, the percentage of solids not fat varying within very narrow limits : thus among 2193 samples of the mixed milk of herds Richmond found it to be between 8.4 and 8.5 in 1892, and 8.3 to 8.4 in 242. In 59 only was it lower, 8.2 to 8.3 in 27, 8.1 to 8.2 in 22 ; 8.0 to 8.1 in 8. and below 8.0 in but 2 cases.

Human milk differs from that of the cow more than is commonly supposed. It not only belongs to the second type, along with those of the ass and the mare, in which the casein is not, as it is in the milks of all ruminants, coagulated

by rennet, though it is possibly due rather to a deficiency of lime salts than to any essential and considerable difference in the constitution of the casein; but it appears that the milk-sugar is not identical with the lactose of cow's milk, since, among other differences, the taste is rarely, if ever, sweet, although the percentage of sugar is considerably higher, averaging 6.8 as against 4.7 in that of the cow. Its reaction, too, is almost always alkaline, and its colour a chalky-white.

There are great discrepancies in the published analyses, due partly to the difficulty attaching to the obtaining of fair samples of the entire contents of the breast, the like difference existing between successive drawings as between the foremilk and the strippings of the cow, and partly to great diversity in the health, food, habits and mental characteristics of different mothers.

The most trustworthy analyses seem to be those of Pfeiffer and of Carter and Richmond, based on 160 and 90 observations respectively:

	Water.	Fat	Sugar	Proteids	Ash.
Pfeiffer . . .	88.22	3.11	6.30	1.94	0.22
Carter and Richmond	88.04	3.07	6.50	1.97	0.26
Maxima . . .	—	9.05 (P.)	8.89 (R.)	5.56 (P.)	0.50 (R.)
Minima . . .	—	0.47 (R.)	4.22 (P.)	0.85 (Leeds)	0.09 (P.)

From his own observations and those of Pfeiffer of the composition of human milks, month by month, during the full period of lactation, Richmond deduces the following as the average composition after the full establishment of the function:

Water . .	88.2	Proteids .	1.5
Fat . . .	3.3	Ash . . .	0.2
Sugar . .	6.8		

In 37 observations made by Mr. Carter on the milk before and after suckling the infant, the only appreciable difference was in the percentage of fat, which was on the

average 2.89 before and 3.18 after the removal of the child. This relative increase was more marked when the excretion was scanty, the percentages in one case having been 0.98 and 4.07, while in one of excessive secretion the proportions were identical.

The difference between human and cow's milks are chiefly in the character of the proteids and the fat, the former differing from those in cow's milk by not being coagulated by rennet, and giving with acid a fine flocculent precipitate, though by adding calcium phosphate these differences are rendered less marked; they behave differently with copper sulphate. The fat of human milk contains much less of volatile, and some free fatty acids.

ABNORMAL AND COLOURED MILKS

Red Milk.—Caused by saprophytes (not pathogenic), *B. prodigiosus*, *B. lactis erythrogenus*, *B. rubidus*, *Spirillum rubrum*, *Micrococcus cinnabareus*, and a red yeast.

Yellow Milk.—*B. synxanthus.*

Blue Milk.—*B. cyanogenus*, *B. cyanco-fluorescens* (of Zangemeister), *B. janthinus.*

Slimy Milk.—*Micrococcus viscosus* (Weigmann and Zion, G. Leichmann).

Bitter Milk.—*Proteus vulgaris* (Hauser), B. of Bleisch, *B. and M. lactis amari* (Freudenreich), and others described by Hueppe, Flügge and Stirling, the bitterness being due to the formation of peptones, as may be shown by the biuret reaction.

Poisonous Milks.—The toxic bodies are ptomaines produced from the albuminous constituents. Such are the tyrotoxicon of V. Vaughan, of Ann Arbor, Michigan, a diazobenzine, and Brieger's spasmotoxin.

CHAPTER IX

DIETETICS OF MILK AND MILK PREPARATIONS

MILK has often been described as a perfect and complete food, but this is true only of the milk of each animal in respect of its own young. For the human adult, and indeed this applies to the adults of all animals alike, it is true in a qualitative sense only, but far otherwise quantitatively; for while the percentage of the three food-stuffs in cow's milk is, proteids 3.4, fat 3.9, and sugar 4.75, the weights of each, water free, in an average dietary are, proteids 5 ounces, fat 3 ounces, and carbohydrates 14 ounces. Taking the proportion of each in turn we find:

	Proteids	Fat.	Carbohydrates.
Man's diet . .	100	60	280
Milk . . .	100	115	140
Man's diet . . .	166	100	466
Milk	37	100	122
Man's diet . . .	35	21	100
Milk	71	32	100

Again, taking the total in each as 100, the proportions of the three work out as

	Proteids.	Fat.	Carbohydrates.
Normal diet . .	22 728	13.636	63.636
Cow's milk . .	28.216	32.365	39.419

These figures bring out clearly the small excess of proteids, the great excess of fat, and the great deficiency of carbohydrates in cow's milk, as compared with a normal average diet for an adult. Since, however, the two non-nitrogenous food-stuffs, the fats and carbohydrates, are, to a certain extent,

convertible, so far that though both are, save under extraordinary conditions, necessary for the maintenance of health, some men, as Professor Förster has shown, depend on the one and others on the other for the larger proportion of the carbon they require, we may combine these, comparing the ratio of nitrogenous and non-nitrogenous constituents, when we shall find the difference to be less conspicuous, thus:

	Nitrogenous	Non-nitrogenous
Normal diet . .	22.728	77.272
Cow's milk . .	28.216	71.784

Since an excess of the albuminoids in a dietary has the effect of stimulating metabolism, or tissue change, and this is further accelerated by an excessive imbibition of water, a milk diet is specially adapted to periods in which growth and repair, which involve a concurrent removal of the effete tissues, are proceeding actively. Such are infancy and convalescence from wasting diseases; but it is equally inappropriate when growth is stationary and repair is slow.

The first stage in the digestion of milk is identical with the change into curds and whey, produced in the dairy by the addition of rennet. Very shortly after having been swallowed, the action of the pepsin and hydrochloric acid of the gastric juice is to throw down the casein as a firm tough coagulum, within the substance of which the fat globules are enclosed, while the whey or serum containing the sugar and salt is soon absorbed. The coagulated casein is then gradually dissolved by the gastric juice, though at first easily reprecipitated by neutralisation, or exhaustion of the acid in the stomach; and, having passed through a jelly-like stage, during which the fat globules escape and cohere, it is ultimately converted into peptones, leaving a small pasty residue (Meissner's dyspeptone). The essential characters in which peptone differs from casein and other albumens are that it is no longer coagulable by heat or reagents, and that it behaves as a crystalloid instead of as a colloid solution, capable of passing through a porous

membrane, and therefore of absorption by the surface of the alimentary tract. It also acquires a progressively increasing bitter taste, first perceptible after half an hour, but ultimately becoming intense, far more so, indeed, than that of the bile, for which it is, when vomited, often mistaken on this ground alone. The digestion of milk is not always completed in the stomach, small coagula passing into the duodenum, where the process is resumed by the trypsin of the pancreas, though in cases of great weakness or of diarrhœa in infants much of the casein may escape digestion altogether and be visible in the evacuations.

Milk presents the advantage of a good mixed diet, easily taken, not requiring mastication and salivation, and under normal conditions fairly digestible. It is, however, less so than it is commonly supposed to be, and though liquid in the cup is transformed so soon as it enters the stomach into a very solid and bulky mass, far more so than minced or well masticated meat.

The utilisation of its solid constituents, though comparing favourably with that of most vegetable foods, is not so perfect as is that of flesh meat or even of hard-boiled eggs, as was conclusively shown by Rubner's experiments on himself, no other food being taken at the same time.

	Duration of Experiment.	Total weight in grammes ingested						Lost per cent. in faeces.			
		Food.	Dry Substance	Nitrogen.	Fat	Sugar	Ash	Dry Substance	Nitrogen.	Fat.	Ash.
Roast Beef.	1 day	3516	919	119.5	71.9		45 7	5.6	2 8	17.2	21.2
	1 day	4306	1100	146 3	62.6		55.9	4.7	2.5	21.1	15.0
Hard biscuits	2 days	1896	495	41.5	206.7		20.9	5.2	2 9	5.0	18.4
Milk.	3 days	7315	945	46.1	285.3	307.2	53.4	7.8	6.5	3.3	48.8
	1 day	2050	265	12.9	79.9	86.1	15.0	8.4	7.0	7.1	46.8
	1 "	3075	397	19·4	119.9	129.1	22.4	10.2	7.7	5.6	48.2
	1 "	4100	530	25.8	160.0	172.2	29.9	9.4	12.0	4.6	44.5

It is only as respects the fat that the loss in a meat diet was greater than in one of milk.

The great digestibility of butter was shown in other experiments in which, together with his ordinary mixed diet he took daily 100 to 200 grammes of bacon fat, which is more easily assimilated than that of beef or mutton, and on other days 200 grammes of butter, when the loss of fat from bacon averaged 12.6 per cent., the least percentage having been 7.8, whereas the loss from butter was only 2.7 per cent.

The casein of milk is coagulated not only by rennet (pepsin) and by the addition of acids organic or inorganic, but also spontaneously by the change of some of the milk sugar into lactic acid, this change being effected by ferments produced by various bacteria, of which the *B. coli-communis*, which obtains access during the milking, is the most frequent and active. This coagulation and antecedent souring occur most rapidly in hot weather, or when the milk is put into imperfectly cleaned vessels, the coating of stale milk in which contains immense numbers of these bacilli that have multiplied in it during the interval.

The casein thrown down by rennet differs somewhat from that precipitated spontaneously or artificially by acids, and the whey left after coagulation by rennet contains a considerable proportion of soluble albumens.

ACTION OF HEAT ON MILK

It is only recently, and in connection with the process of sterilisation, that attention has been directed to the changes, physical and chemical, effected by the prolonged action of heat on milk.

At temperatures exceeding 60° C. [140° F.], if the milk be exposed to the air, a skin forms on the surface, which, though of the nature of a proteid, is neither milk albumen, nor casein, but probably an oxidation product or derivative of the latter.

At 70° C. [168° F.] the albumen undergoes a change; it is

not precipitated, but is converted into a form that is precipitated by acids, magnesium sulphate, and other reagents that coagulate casein.

At 80° C. [176° F.] the taste and odour of the milk are altered, concurrently with and apparently in consequence of a change undergone by certain organic principles the nature of which is at present unknown, but the existence of which before these changes is inferred from the effects of certain reagents, which are not produced after the milk has been acted on by heat.

At 100° C. [212° F.], or boiling-point, calcium citrate is deposited, and if the milk be kept at this temperature for some time, further oxidation takes place, traces of formic acid appear, with a marked reduction of the rotatory power of the milk sugar, which is partly converted into caramel, imparting a brownish hue to the milk; a deposition of salts and perhaps of albumen also occurs on the fat globules which expand and coalesce, and on cooling rise slowly to the surface.

Boiled Milk.—Whether raw or boiled milk is the more easy of digestion is a matter on which authorities differ, variously interpreting the few available facts. Boiled milk is less readily curdled by rennet, probably in consequence of the precipitation of the calcium salts, rather than of any change chemical or molecular in the casein itself. But digestion consists essentially, not in the formation but in the subsequent solution of this coagulum, and it is probably in consequence of the less rapid coagulation of boiled milk in the stomach that the curd produced is far less bulky and tough than that of raw milk, and its loose broken texture enables the gastric juice to exert its solvent action to greater advantage, this being really a question rather of the ratio of surface to mass than of the unimportant differences between the several forms of casein; and any imagined analogy between the boiling of eggs and of milk is wholly fallacious, the behaviour of casein under the influence of heat being totally unlike that of egg albumen.

The alleged tendency to scurvy or scurvy rickets in infants brought up on sterilised milk is, to say the least "not proven," and appears to have been suggested by analogy with that occurring amongst ships' crews subsisting on preserved foods, an analogy which loses all its force in face of the recent explanation of this hitherto obscure disease as a chronic ptomaine poisoning, since it is thus due to the consumption of *imperfectly* preserved foods, not to that of those recently sterilised.

The observations of Fleischmann on the action of rennet on milk are not without value in connection with the digestion of casein, and the preparation of milk products for consumption. Rennet acts on casein in neutral or acid solutions only, and more rapidly the greater the acidity. Alkalies arrest and ultimately destroy it. Dilution with water delays the coagulation and renders the curd more flocculent. Heating the milk also delays it, through precipitating some of the lime salts, but it takes place immediately on the addition of a soluble calcium salt as the chloride. Like all enzymes rennet has an optimum temperature of 41° C. [105.8° F.], at or within a few degrees of which one part of rennet can coagulate 100 of milk, the proportion diminishing both upwards and downwards to 18 parts at 20° C., and 50 at 50° C. The curd at or near the optimum is very firm, but that produced at temperatures over 50° C. or under 20° C. is very soft and flocculent.

SKIMMED AND SEPARATED MILK

Theoretically these consist of the milk from which the fat has been removed, the solids not fat, or casein and sugar, as well as the salts, remaining, and in percentages apparently because relatively higher than before the abstraction of the fat. In ordinary skimmed milk the removal of the fat is incomplete, and further risings take place for some time, but any superior dietetic value on this score over the separated milk is more than outweighed by the incipient sourness

which precedes, and indeed is a condition of the so-called spontaneous rising of the cream. This sourness, though no drawback to its use by the baker, confectioner, or even the cook, renders it undesirable as a drink, and positively dangerous to young children and infants.

Separated milk, on the other hand, though still poorer, indeed practically devoid of fat, presents the advantage of being perfectly sweet, and constituting a cheap, pleasant and wholesome beverage, the sale of which, especially retail over the counter or bar, well deserves to be encouraged in every way. It is a great error to describe such milk as having been deprived of its "goodness"; the absence of the fat unfits it for infant feeding, or for sick persons on an exclusively milk diet, but though it cannot serve as the sole nourishment of infant or adult, it is none the less wholesome and nutritious as a part of a mixed diet, and certainly more so than beer. The casein and the sugar are as necessary as the fat, if not more so; and it would be equally incorrect to say that there was no nourishment in a slice of good and palatable bread because it was not spread with butter.

The sour skim milk not taken by bakers should be given to the pigs, but separated milk sold, or given to the poor as a drink, with the strict reservation that it is wholly improper for the infant's bottle. Skim milk from the Jersey creamer is also free from sourness, though the centrifugalised milk having been freed in the process from the slime and a large proportion of the bacteria, is likely to remain sweet longer.

While the average composition of entire milk is:

	Per cent.		Per cent.
Water . .	87.10	Casein . .	3.00
Fat . .	3.90	Albumen . .	0.40
Sugar . .	4.75	Ash . . .	0.75

that of well separated milk is:

	Per cent.		Per cent.
Water . .	91.50	Casein . .	3.15
Fat . . .	0 10	Albumen . .	0.42
Sugar . . .	4.95	Ash . . .	0.78

In hand-skimmed milk the proportion of fat is much greater, ranging from 0.4 to 2.0 per cent., the limits rarely overpassed in the case of separated milk being .05 and 0.3 per cent.

The spontaneous rising of the cream is most rapid and complete when the milk is "set" to cream immediately on having been drawn from the cow.

Whey contains little more than the sugar, 4.3 to 5.8 per cent.; the proteids never exceeding 1 per cent., and the fat 0.2 to 0.4 per cent.

BOILING, STERILISING, AND PASTEURISING

These procedures are so far the same in that they consist in the exposure of the milk to the action of heat at such temperatures and for such times as may be necessary for the destruction of all bacteria therein. In simple boiling, if continued long enough, this end is attained most completely, but at the cost of changes in the sensible properties of taste, &c., if not of others affecting its nutritive value. Sterilising and Pasteurising aim at achieving the same end without these drawbacks, and with this view the latter is conducted at the lowest effective temperature, while the former, aiming rather at thoroughness, is carried out at the highest temperatures, but for the shortest time compatible with complete sterilisation, and seeks to avoid oxidation processes by the exclusion of atmospheric air, so far as is practicable, by the substitution of water vapour.

Pasteur, while fully aware that the sterilisation of serums and other fluids could be ensured by boiling, sought to attain the same result without the unavoidable changes in the unstable organic principles which would render them inert, and before the discovery by his assistant, Dr. Chamberland, of the germ-proof filter that goes under their joint names, found that he could obtain this result by exposure for some time to a temperature of 70° C.

This, however, while sufficient to kill all, or nearly all, growing bacteria, failed to destroy the vitality of their spores. This defect he overcame by repeating the heating at intervals, during which the fluids were kept at the ordinary or optimum temperatures for the germination of the spores until they were exhausted. This process was, however, too tedious for practical application in the case of milk and in dairy work, sporiferous bacteria being of exceptional occurrence. The term Pasteurising is used to designate a single exposure for ten or fifteen minutes to the temperature of 70° C., which is sufficient to destroy such growing bacteria as are usually present.

Pasteurisers, as used in creameries and butter factories, are apparatus in which a constant stream of milk is kept flowing over a coil of hot-water pipes in almost precisely the same way as it is over pipes in which a current of cold water is maintained in refrigerators.

When, however, the milk is intended for preservation in bottles for indefinite periods, and the utter destruction of all germs, including spores, is absolutely necessary, recourse must be had to temperatures considerably above the boiling-point, and the process must be conducted in close chambers filled with vapour under a pressure of several atmospheres, and it is to such apparatus alone, of which the most perfect is the "Sterilikon" of Messrs. Flaack, that the description of sterilisers is strictly applicable. Aymard's, which are simply jacketed saucepans or water-baths, and those in which the bottles of milk are kept for some time immersed in a barrel or cistern of boiling water, however useful for domestic purposes, belong to a totally different class. They may sterilise the milk for a time, but cannot be relied on to do so permanently, since the temperature cannot be raised above the boiling-point of water, and if the heat be maintained long enough to ensure even temporary sterilisation, the changes induced thereby in the presence of air are unavoidable.

In such as Ffaack's, however, while the most resistent spores are effectually destroyed, the exclusion of air hinders oxidation processes, the formation of the "skin" and the conversion of the sugar into caramel, while the high temperature effects the sterilisation in a much shorter time. Such milk, in fact, while absolutely sterile, is scarcely to be distinguished in taste and appearance from the fresh.

For a description of these various appliances see the chapter on the Dairy.

CONDENSED MILKS

The manufacture of condensed milk, which had its origin in Switzerland about the middle of the last century, has been taken up also in Germany, Norway, England, and elsewhere, and has attained enormous proportions.

Condensed milks are of two classes, sweetened and unsweetened, and are prepared from whole or from separated milk. The preparation of both is similar, except that for the unsweetened the milk is previously sterilised, a precaution rendered superfluous in the others by the addition of an excess of sugar.

The chief feature of the process is the use of the so-called "vacuum pan," or oven in which the air is kept by the working of an air pump at such a state of rarefaction that the milk shall "boil" at a temperature too low to cause browning and the other changes incident to exposure to temperatures of 100° C. (212° F.) and upwards. The milk, after 1¼ pound of cane sugar has been added to each gallon, is raised to such a temperature that it may begin to boil immediately on being brought into the rarefied atmosphere of the vacuum pan. Into this it flows slowly, while the pump, kept working all the time, draws out all the gases and air dissolved in the milk, so that when the whole of the milk has been admitted, and heat is applied, it boils without frothing over. By carefully regulating the supply of heat to the pan, and of cold water to the condenser, the progress

of the operation being watched through a glass plate in the roof of the chamber, the condensation is carried on at a rapid but uniform rate until completed. The condensed milk has then a density of 1.28, its weight being one-third and its volume three-elevenths of that of the original milk—*i.e.*, one gallon has been evaporated down to 2¼ pints, or each tin represents about a quart of milk.

COMPOSITION OF SWEETENED CONDENSED MILKS

Authority	Water	Fat	Milk Sugar.	Cane Sugar	Casein & Albumen.	Ash	Total
Richmond	24.06	11.28	13 97	38.31	9 36	2.13	99.11
Pearmain and Moor	26.10	10.84	14.68	36 93	9 55	1.90	100 00
Fleischmann	25 69	10.98	16.29	32.37	12 33	2.34	100 00
König	26.70	9.76	51 02		10.20	2.32	100 00

SWEETENED CONDENSED SEPARATED MILK

Richmond	29.05	1.28	14.0	40.07	10.74	2.33	98 27
Richmond	29.23	0 64	15.50	40.19	10 03	2 68	98.02
Richmond	28.43	0 36	16.88	39 27	11.73	2 58	99.25
Pearmain and Moor	29.87	1.17	14.68	41.54	10.74	2 00	100 00

UNSWEETENED CONDENSED MILK (WHOLE MILK)

Richmond	63.17	10 22	12.98	—	10.30	2.07	99.04
Richmond	62.40	11.91	13.04	-	9 68	2.14	99 17
Richmond	63.07	10.86	13.38	--	9.80	2 21	99 32
Pearmain and Moor	61.96	10.67	15.50	—	9.57	2.30	100 00
Aschmann	69.35	9.23	10.98	-	9.41	1 63	100.00
König	61.87	11.26	13.35	--	11 38	2.22	100.00

In those in which the totals are under 100.0 the loss is probably sugar, which adhered to the fat.

Dilution.—Since a gallon of normal milk is represented by a little over a quart of condensed milk, the former could be imitated by diluting the latter with three parts of water; or if for infants for whom it is usual to dilute fresh milk with water in the proportions of 1 : 1 or 2 : 1, one part of condensed milk should be dissolved in four or five of water. If the condensed milk be unsweetened the results would be as satisfactory or unsatisfactory for the purpose of infant

feeding as the corresponding dilutions of the natural milk; but with the sweetened milk fresh difficulties arise, since the amount of sugar is excessive. To reduce this to a more suitable percentage it is usual to carry the dilution further, but by so doing the fat is brought far too low.

The directions printed on the tins are to dilute the milk with five to seven volumes of water; they are, however, not as a rule, strictly carried out, since while the water is measured correctly by the spoonful, those of the thick milk are always heaped. But supposing these to be equivalent in bulk to those of the water, we have:

	With 5 vols of water.		With 7 vols. of water.	
Fat	2.02		1.51	
Milk sugar	2.57	9.90	1.93	7.43
Cane sugar	7.33		5.50	
Proteids	1.83		1.37	
Ash	0.40		0.30	

The percentages in human milk are fat 3.3, milk sugar 6.8, proteids 1.5, ash 0.2; or the fat in the diluted condensed milk is from $\frac{2}{3}$ to $\frac{1}{2}$ of what it should be, and the sugar from $\frac{1}{6}$ to $\frac{1}{3}$, that is the preponderance of sugar is approximately equivalent to the deficiency of fat.

If, however, with Rubner we assume the food value of one part of fat to be equalled by 2.43 of sugar, the combined equivalents become 14.82 for human, and 14.61 for sweetened condensed milk diluted with five parts of water, or practically identical, while the percentages of the proteids, 1.50 and 1.83, are not materially different. But though many infants do thrive on condensed milk thus diluted, and apparently do not suffer in any way from the abnormal and inverse proportions of fat and sugar, it is no less certain that in the economy of the living, and especially of the growing organism, the special functions of fat cannot be perfectly fulfilled by the carbohydrates; some factor in the promotion of the general process of nutrition being wanting, as is manifested in the improvement that

follows the use of cod-liver oil. Thus, while some infants reared exclusively on condensed milk enjoy perfect health and show the fullest development, others, though fat and happy, manifest a tendency to rickets and imperfect ossification. The addition of a little cream to the diluted condensed milk will, however, often completely obviate these results, by supplying the fat that would otherwise be wanting, while the poor, and persons who have a difficulty in obtaining cream, may find a substitute little inferior in melted bacon fat, which children take with avidity. Much, however, of the starvation that seems to follow the use of condensed milk is really owing to its being unduly diluted, in consequence of exaggerated notions of its concentration. Thus it is no infrequent practice to dilute it with ten or more parts of water; in fact, the directions on the wrappers of some brands recommend, in the case of young infants, the addition to one part of milk of fourteen of water. Happily, if spoons are used, they are usually heaped, for this attenuation would bring down the percentages to 0.5 of casein, 0.5 of fat, and 1.0 of milk sugar, instead of the 2.0, 4.0 and 6.8 of mother's milk; the presence of 3.0 per cent. of cane sugar being a doubtful advantage. It is, however, but fair to say that the effect of the prolonged heat to which the milk has been subjected in the process of condensation, seems to be to render the coagulum of casein formed in the stomach less dense than that of raw milk, and therefore more easily digested. It is a familiar observation that during the early weeks, perhaps so long as to the third month of infant life, condensed milk is, as a rule, better borne than fresh cow's milk. The fact, too, of its being always fresh and sweet, is of the greatest importance: that is, assuming that the water is heated, and the milk mixed afresh every time it is wanted.

Whether fresh or condensed milk be used, this should always be done, for the temperature of the living body being the optimum for the growth of the germs always present in

dairy milk and equally so in the air of the dwelling room, the "night warmer" constitutes an incubator, in which the bacteria will multiply a thousandfold in the interval between the mixing and the giving of the bottle.

The use of any such contrivance cannot be too strongly deprecated, as tending to induce diarrhœa and gastric intestinal disturbances, their sole claim for favour being the saving of trouble to the mother or nurse in the night, although a perfectly healthy infant may easily and early be taught to sleep for six hours or longer in the night without rousing for the bottle.

It would seem superfluous to point out the utter unfitness of condensed skimmed milks for infant feeding, were it not that among the ignorant poor, especially those women who come more or less under the description of "baby farmers," its cheapness presents an irresistible temptation.

Unsweetened condensed milks, when diluted with three or four times their volume of water, reproduce almost perfectly the milk from which they were made, and may be manipulated with water and milk sugar as fresh milk would be.

They are, however, far less stable than the sweetened, souring if exposed to the air for more than two days; and they are for this reason usually put up in tins, with two very small perforations for the escape of the milk and the entrance of air.

Humanised Milks.—Much ingenuity has been applied to the working out of methods for so modifying the relative proportions of the constituents of cow's milk as to approximate more nearly to those of human milk.

Now, while Richmond found the average percentages in 200,000 samples of cow's milk to be

Proteids	3.40
Fat	3.90
Sugar	4.75

those in human milk were

Proteids	1.50
Fat	3.80
Sugar	6.80

or as averaged from the observations of Pfeiffer, Hoffmann, Leeds, and Luff

Proteids	1.83
Fat	3.63
Sugar	6.66

In short, while the percentage of fat is practically the same in each, human milk contains more sugar, and cow's milk a great excess of casein, and that of a less digestible character. Dr. Pavy proposed to remove a part of this by means of rennet, but his method has fallen into oblivion, and recourse is had alike in factories and in the nursery to simple dilution with water; but it is obvious that in thus bringing down the casein to the human standard, the fat, present in proper amount, is reduced in like manner, and the sugar already deficient, is made more so.

The effect of different degrees of dilution on the several constituents of cow's milk may be shown thus:

	Proteids	Fat	Sugar
Human milk	1-2	3-4	6-7
Cow's milk, pure	3.40	3.90	4.75
Cow's milk, 2 pints Water, 1 pint	2.26	2.60	3.16
Cow's milk, 1 pint Water, 1 pint	1.70	1.95	2.37
Cow's milk, 1 pint Water, 2 pints	1.13	1.30	1.58

While, however, the proteids must be taken as they exist in the milk, and are amenable to dilution only, the deficiency of sugar may be made up perfectly by the addition of milk sugar, or less perfectly of cane sugar, and that of the fat by adding cream, save that this, after it has once been removed from milk, refuses to mix as completely as before, in consequence of the partial coalescence of the globules, though if a very weak cream be used this difficulty is less felt. The cream sold in the shops, however, varies greatly in consistency, and is often in a state of commencing sourness, or has been charged with preservatives.

Dr. Ashby's directions are to put 1½ pints of good fresh

milk as soon as received into a bottle such as is sold with Hawksley's Steriliser. Its neck having been closed with a plug of clean non-absorbent cotton-wool, the bottle is to be stood for six hours in ice or in the coolest place available; some cream will have risen, and the lower half, or 15 ounces of the milk, should then be *siphoned* off, and replaced by an equal volume of a 7 per cent. solution of sugar of milk, *i.e.*, 1 ounce of the sugar in 15 ounces of water. The bottle is then placed in the steriliser for half an hour, at a temperature of 160° F. It is then to be quickly cooled in ice or running water, and kept so till wanted, when so much as is required for the infant's meal is put into the feeding-bottle and warmed up to 100° F. Such a mixture contains about 1.8 proteid, 3 to 3.5 fat and 6 milk sugar.

For very young weakly infants this may be too strong, and 20 ounces instead of 15 should be siphoned off and their place taken by 20 ounces of water containing 1 ounce of milk sugar. In all cases a few grains of bicarbonate of soda or drops of saccharated solution of lime may be added with advantage, to render it, like human milk, slightly alkaline.

Dr. Ashby gives, on the authorities of Holt and Westcott, tables for the mixing and dilution of the cream rising on milk, kept surrounded by ice or iced water for about six hours, which, if removed to the extent of 6 ounces from the quart of milk, will contain approximately 12 per cent. of fat.

It may be (1) diluted with sugar water, or (2) with whole milk and milk sugar. Since, however, all methods involving the spontaneous rising of the cream are open to the objection that more or less souring is inevitable, it would be much better, could a uniformity of strength be relied on, to have 12 per cent. cream, perfectly sweet and fresh from the separator, supplied daily, the same formulæ being observed.

FORMULÆ

Obtained by diluting 12 per cent. cream, with solution of milk sugar (in formulæ 1 and 2, the solution should be 1 ounce to 16½ of water, and in 3, 4 and 5, 1 ounce to 14 of water). Holt.

	Cream	Sugar sol		Fat	Proteids	Sugar.
(1)	1 part to	5	parts	2.0	0.6	6.0
(2)	,,	4	,,	2.5	0.8	6.0
(3)	,,	3	,,	3.0	1.0	6.0
(4)	,,	2½	,,	3.5	1.2	6.0
(5)	,,	2	,,	4.0	1.3	6.0

The next table (Westcott) shows the quantities of 12 per cent. cream, whole milk and milk sugar required to obtain the several percentages of the constituents in the mixtures.

Cream Oz.	Milk Oz	Milk Sugar Oz		Fat Per cent	Proteids Per cent	Milk Sugar. Per cent
2.3	13.0	1.75	gives	2.0	1.5	6.0
4.8	10.6	1.75		2.5	1.5	6.0
7.3	8.1	1.75		3.0	1.5	6.0
9.8	5.6	1.75		3.5	1.5	6.0
12.3	3.1	1.75		4.0	1.5	6.0

and, in all, water to make up 40 ounces = 1 quart.

Since, however, the poor, and many who are not poor, but at a distance from good dairies, cannot afford or obtain fresh cream, the great majority of mothers who are unable to suckle their infants will have to be content with diluted and sweetened milk. The dilution will, it is true, unduly reduce the fat, unless the milk be exceptionally rich in natural cream, and probably some of the casein will pass undigested as small white curds in the fæces; but it must be admitted that many infants thrive well on this simple arrangement, and when they are six months old the yolks of raw or very lightly boiled eggs may be given once a day to provide the fat which is deficient in the diluted milk. Common brown sugar should never be used, the finest white crystalline cane sugar only is permissible, but milk sugar itself is greatly to be preferred, and if possible should be used exclusively. The price, 1*s.* 3*d.* per lb., is not a serious consideration, and its neglect can be explained only by the ignorance of the laity of its great superiority in the freedom from any tendency to

fermentive changes in the stomach. For the first three months the milk should be diluted with an equal volume of a solution of one ounce of milk sugar in 20 ounces (1 pint) of water, and from that time to the age of six or eight months with half its volume, two parts of milk to one of a solution of one ounce of milk sugar in 15 of water, one-twentieth being lime water in every case.

In the first three weeks after birth milk even thus diluted may be ill borne by the infant, and it would then be well to try a sweet fresh whey prepared by warming 30 ounces (1½ pints) of fresh milk in a large wide-necked bottle, or a clean enamelled saucepan, to 104° F.; adding a teaspoonful or two of Benger's essence of rennet, allowing it to stand until coagulation has taken place, and after stirring and agitating it to break up the curds and liberate the entangled fat, straining through a fine hair sieve or muslin. The 30 ounces of milk will yield about 23 ounces of whey, containing fat 1.5 to 2.0 per cent., proteids 0.8 to 0.9 per cent., milk sugar 4.75 per cent., and salts 0.6. The whey should then be sterilised, and may require straining again to remove such small proteid coagula as may have been formed since the separation of the larger curds.

By degrees milk and with it a little more milk sugar may be added to the whey. A weak humanised milk may be made by mixing 10 ounces of fresh milk with 20 ounces of this whey and adding ½ ounce of milk sugar, and a stronger by substituting for the milk a thin 8 per cent. cream.

In digestive disturbances of older infants whey alone, or diluted with barley water, will often be of great benefit, given in place of the usual diluted milk, until the attack has subsided.

Dr. Rotch, of Boston, U.S.A., was the first to study this question exhaustively, and to establish a laboratory or factory where humanised milks with any desired percentages of the proteids, fat and sugar, could be prepared to the prescriptions of medical men; but of late years all the great

dairy companies have made more or less of a specialty of humanised milks, though rarely, if ever, adapting the product to the needs of individual cases.

The best and most scientific of these processes is that of Dr. Gaertner, for which one company claims to have exclusive rights in this country, though the validity of the pretension is more than doubtful, no single step in the procedure being capable of legal protection. Good fresh milk, diluted with an equal volume of hot water, is centrifugalised at such a velocity that the richer and poorer portions pass out *at the same rate*; milk sugar is then added to the richer half (or *fett Milch*, as Dr. Gaertner calls it) in the proportion of 35 grammes to the litre = 5 drachms to the pint (and for infants under one month one part of barley water to two or three of milk before use).

Some companies achieve the same result by substituting for the centrifugalisation a modification of the Schwartz or Jersey method of raising cream, but with scarcely the same accuracy and constancy in the result. Such humanised milks must be thoroughly sterilised in the bottle before being sent out, since the least failure in this respect may render them unwholesome in the extreme and bring the method into disrepute.

The small table separators are well suited for Gaertnerising milk at home, and their price brings the process within the means of all but the poorer classes of the community, while the apparatus may be used for other domestic purposes for which cream is wanted.

A practice has of late been widely adopted, and, on the whole, with fairly good results, of diluting the milk for infants with thin mucilaginous fluids, as barley water, very thin arrowroot, or weak oatmeal gruel strained from all solid particles. It is based on the fact that the tendency of the casein to form large tough curds in the stomach is thereby lessened; but since the saliva of a young infant has no action on starch, no more should be used than is absolutely necessary

for securing the end in view. Dr. Franklin W. White, of Philadelphia, has shown that this is not attained so long as the starch is present in quantities below 0.5 per cent., but that while 0.7 per cent. gives a fine flocculent coagulum, no better result is obtained by using 1.0 or even 1.5 per cent.

The proportion should therefore be not less than 0.7 nor more than 1.0 per cent.; and though it is of no importance what form of starch is used, the difficulty of standardising crude decoctions of barley or oatmeal in domestic practice points to the desirability of using some form of pure starch, as arrowroot or cornflour, in the proportion of 75 to 90 grains to the pint of cow's milk, or of a little over one drachm, approximately a full but not heaped teaspoonful to a pint of the milk as diluted for use. The starch must be well boiled, and should therefore be added to the water and boiled with it until completely dissolved and uniformly diffused throughout. Malted foods in which the starch is entirely converted into dextrin and sugar, of which Mellin's food is the most perfect example, are less effective.

However closely the composition of cow's milk may by these procedures be assimilated to that of human milk in the percentages of the constituents, the fact remains that by no manipulation can the physical differences between the casein of cow's and of human milk be overcome. The casein of asses' milk, however, behaves as does that of human milk; and Klemm, Von Ranke, and Parrot have conclusively proved the immeasurable superiority of ass's to cow's milk, and even to that of wet nurses, in the case of feeble infants, notwithstanding its low percentage of fat; for, necessary as a due supply of fat is to the growing infant, its importance in very early life, and in great weakness of the digestion, falls into comparative insignificance before that of the digestibility of the casein.

Objections, purely theoretical, have been raised to the practice of boiling or sterilising milk on the assumption that the presence of bacteria was in some way conducive to

digestion. This notion appears to have been based on the false analogy of the vast importance of the action of bacteria in the nitrification of organic matter in the soil, the origin of nearly all ferments out of the living body as products of the vital processes of bacteria, and the presence of enormous numbers of bacteria in the bowels of, as was thought, all animals. It appeared too, to receive confirmation from the experiments of Nuttal, Thierfelder, and Schottelius, who failed to rear the young of rabbits and fowls, brought into the world under strictly aseptic conditions, and fed on sterilised food and water, such young animals not increasing in weight, and dying within a few weeks of birth. But these experiments were falsified by the very unnatural conditions under which the animals existed, and it seems that the absolute sterility of the milk as drawn directly from the breast or udder was ignored. But the observations made in the Arctic regions by Dr. Levin of Stockholm on animals living under perfectly natural conditions have utterly exploded all notions of the necessity of the presence of bacteria in the stomach and intestines, or in the food itself for its proper digestion, and the nutrition of the animal. He found that in Spitzbergen and in Franz Joseph's Land earth and air were alike entirely free from bacteria of any kind and the contents of the bowels of land-feeding animals were absolutely sterile. A few bacteria were present in the water of the ocean, and those which were in rare instances detected in the intestines of seals, water-fowl and fishes were evidently introduced with the sea water that they swallowed with their food, for none were ever discovered in those of foxes or rodents, and the elsewhere ubiquitous *B. coli communis* was never found.

Still, the question of the milk best adapted to each infant is not one to be decided by mere chemical analysis, and no hard and fast rule as to its composition can be drawn. A milk on which one infant thrives will in another give rise to gastric disturbance, and lead to rickets or starvation. Aver-

ages are in general correct as to numbers, but for individual cases they are fallacious and dangerous. Women's milks vary far more than those of cows; and we may presume that when an infant thrives on that of its own mother, though judged by averages it be quite abnormal, it would not do so well on the milk of another woman, though its composition were all that it should be.

Dr. Charles Harrington, of Harvard University, one of the highest authorities in America, analysed the milks of fourteen healthy mothers whose infants were all strong, gaining in weight, and digesting the respective milks well. The results were startling, and wholly subversive of commonly accepted notions.

	Fat	Sugar.	Proteids	Ash	Tot. Solids.	Water
I.	**5.16**	**5.68**	4.14	0 17	15.15	84.85
II.	4 88	6.20	3.71	0 19	14.98	85.02
III	4.84	6.10	**4.17**	0.19	**15.30**	**84.70**
IV.	4 37	6.30	3.27	0.16	14 10	85.90
V.	4.11	5.90	3.71	**0.21**	13.93	86.07
VI.	3.82	5.70	**1.08**	0 20	10 80	89.20
VII.	3 80	6.15	3 53	0.20	13 68	86.32
VIII.	3.76	6.95	2.04	0.14	12 89	87.11
IX.	3.30	**7.30**	3 07	**0.12**	13 79	86 21
X.	3.16	7.20	1.65	0.21	12 22	87.78
XI.	2.96	5.78	1.91	0.12	10 77	89.23
XII	2.36	7 10	2.20	0.16	11.82	88 18
XIII.	2.09	6.70	1 38	0.15	**10.32**	**89.68**
XIV	**2.02**	6.55	2 2	0.15	10.84	89 16
Mean .	3.62	6.40	2.71	—	12.99	—

They are arranged in this table in the order of the percentages of the fat, although it is the proteids, and not the fats, as in the milk of the cow, that show the greatest variation; for while the fat ranges between 2.02 and 5.16 with a mean of 3.62, the proteids average 2.71 with extremes of 1.08 and 4.17; the sugar is the most constant, the lowest being 5.68 in No. I. (accompanied by the maximum of fat, and very nearly that of the proteids also), and the maximum 7.30, the mean being 6.40. The total solids range from 10.32 in No. XIII. to

15.30 in No. III., which is the richest on the whole, No. I. coming next in order, and the mean is 12.99. In other words, the extremes of the proteids are nearly as 1 : 4, of the fat as 1 : $2\frac{1}{2}$, of the sugar as 1 : $1\frac{1}{4}$, while those of the total solids are as 1 : $1\frac{1}{2}$.

As regards the percentage of fat, only the milk of No. I. rivalled, if it did not exceed, that of good Jersey cows; while Nos. XI.–XIV. were poorer than those of any British cattle, XII.–XIV. being more so than even the Holstein, whose yield, though the largest, is the poorest of all well-recognised breeds. In this connection it is at once interesting and suggestive that there is much in common between the milks of the average human female and the despised Holstein cow, and striking physical contrasts between these and the vaunted Jerseys and Guernseys, their milk being far the richest in the "volatile glycerides" of butyric, caproic and caprilic acids; while that of the Holsteins yields but little of these, and contains the largest proportion of the stable fats, as olein and stearin.

Again, the globules are largest in the milk of Jerseys and the like, and smallest in that of the Holsteins and woman, the emulsion in the latter being the more stable, and easily restored even after much of the cream has risen; whereas those of the former coalesce as they rise as large oil drops to the sides of the vessel, when no agitation, however continued, will restore the emulsion to anything approaching its original condition.

These volatile glycerides do not exist in the milk before it leaves the udder, but are formed subsequently. It is their presence which imparts the delicious flavour to fresh butter, but later they become the cause of rancidity, and may, after ingestion, set up serious gastric and intestinal trouble.

Dr. Rotch, arguing from the fact that the milks of different mothers, though presenting the greatest diversity of composition, agreed equally well with their own children, though disagreeing with others, conceived the idea of a factory or

laboratory where a milk of any desired character, from, *e.g.*, No. I., with F. 5.16 and Prot. 4.14 to No. XIII. with F. 2.09 and Prot. 1.38, could be made to order on the prescription of a medical man, just as one for medicine would be made up by a pharmaceutical chemist. The first of these "Walker-Gordon laboratories" was opened at Boston in 1891, and has been ever since conducted by Dr. Rotch, but there are now some eighteen in the United States and Canada. Here are kept at all times, fresh and ready for mixing, the materials, viz., sterilised water, creams with different percentages of fat, fat free milk, milk sugar, whey, and several forms of starch or farinacea. The perfectly white cream of the Holstein cows is preferred, since the smallness of the fat globules, the stability of the emulsion, and the ease with which it can be restored after having been broken, render it specially amenable to mixing processes. So far as the emulsification is concerned, no difference whatever is found in the use of "gravitation" or "centrifugalised" cream; but the latter being always fresh and sweet, and the percentage of fat capable of being regulated with the greatest exactness, is preferred.

The modifying- or mixing-room must be kept as nearly asentic as possible by the use of glazed tiles, sheet glass tables, &c., and the exclusion of dust by straining the incoming air in ventilators, while light is admitted by windows fixed in their frames, and the room is entered through a vestibule with double spring doors. The attendants, in sterilised clothes, are not allowed to leave the room until their day's work is done, and no visitors or other unauthorised persons are permitted.

Dr. Rotch does not look with favour on the ordinary methods of sterilising milk, but prefers obtaining it germ-free, or practically so, which can be done by milking the cow with every antiseptic precaution, throwing away the first draught from each quarter, and avoids exposing the milk or whey to temperatures exceeding 69° C.

Dr. Rotch's conclusions as to the use of whey, instead of whole or separated milk, as a diluent of creams of various strengths, are, that the proportions of what he distinguishes as caseinogen and whey proteids are thereby more easily regulated and approximated to those observed in mother's milk. From a maximum of whey proteïds of 0.90 to a minimum of 0.25 per cent., combined with percentages of caseinogen of 0.25 to 1.00, of fats 1.00 to 4.00, and of milk sugar 4.00 to 7.00 per cent., the coagula in whey mixtures were extremely fine, even more so than in barley water. The best temperature for destroying the rennet enzyme in whey is 65.5° C. (150° F.), and the mixture should not be subjected to above 69.3, as the whey proteïds are coagulated at that point. He believes that 68° C. = 155° F. suffices to kill all pathogenic bacteria, while leaving the milk "uncooked."

Dr. Rotch's work is highly esteemed in America, and the numerous Walker-Gordon laboratories are extensively patronised by the younger and more scientific members of the medical profession, with results greatly appreciated by the public; but in the discussion on the paper read by him at the meeting of the British Medical Association in 1902, some of his conclusions were much criticised. Dr. Adolph Baginski of Berlin, probably the highest living authority on the health and diseases of children, expressed his belief that the problems of infant feeding had not been so far solved as to admit of exact treatment by prescriptions, and maintained that such modified milks as Gaertner's, though perfect in theory, were often followed by diseases of nutrition as rickets, and the combination of rickets and scurvy, known as Barlow's disease.

A perfectly healthy infant will mostly let go the nipple or teat when it is sensible of having had enough; but while it should on no account be encouraged to finish off a bottle merely to avoid "wasting" what is left, the lesser labour involved in artificial than in natural nursing is very apt to lead the child to take more than is good for it, with the

consequence of repletion, flatulence, acidity, and irregularity of the bowels. The amount of fluid given at a meal should be adjusted to, though always somewhat greater than, the actual capacity of the stomach at the particular age. Thus, Frolowski found this to be—

At birth . .	nearly 1 ounce	At two month .	nearly 3½ ounces
At one month .	„ 2¼ ounces	At four months .	„ 3¼ ounces

and Dr. Rotch, whose figures correspond very closely with those of the best authorities, gives as the means of observations by 278 medical men on 774 infants fed on the "modified" milks from the Walker-Gordon laboratories, all digesting well and gaining weight, the following:

Age.	Average amount in ounces taken at a meal
1 day to 4 weeks	0 988 to 2 355 about 1–2½
4 weeks to 8 „	2 335 „ 3.220 „ 2½ 3¼
8 „ 12 „	3.220 „ 3 969 „ 3¼–4
12 „ 16 „	3 969 „ 4 574 „ 4–4½
16 „ 20 „	4 574 „ 5.284 „ 4½–5¼
20 „ 24 „	5.284 „ 5.719 „ 5¼–6
24 „ 28 „	5.719 „ 6 187 „ 6
28 „ 32 „	6 187 „ 6.953 „ 6 7
32 „ 36 „	6 953 „ 7·544 „ 7–7½
36 „ 40 „	7 514 „ 7 894 „ 7½–8
40 „ 44 „	7 894 „ 8.071 „ 8
44 „ 48 „	8 071 „ 8 231 „ 8 8¼
48 „ 52 „	8 231 „ 8 254 „ 8¼

The apparent anomaly of the amount of milk recommended at each meal being greater than the capacity of the stomach at the given age, is explained by the passage of the watery part or whey into the intestine, that goes on simultaneously with the ingestion of the milk, and the elasticity of that organ; though, if distended beyond a certain point, the symptoms of repletion follow. The gastric juices are not secreted in quantities capable of dealing with the excess of milk, the lactic fermentation is attended with the evolution of CO_2, adding to the distension and interfering with respiration, and perhaps with the action of the heart, and masses of undigested curd pass on into the bowel, leading to

disturbance of the further process of digestion, and to putrefactive changes, giving rise to flatulence, colic, and diarrhœa.

Lactic acid fermentation, caused normally by the ubiquitous *B. acidi lactici* of Hueppe, and the *B. lactis aerogenes* of Escherich, occurs naturally in the stomach, but is arrested, or at least checked, when the acid has been formed to the extent of one per cent. of the contents, and according to some authorities prevents the occurrence in the stomach of butyric and other undesirable fermentations. The latter are, however, induced to abnormal amounts by the *B. coli communis* and its associates. The growth of the infant's stomach is very great and rapid in the first three months, less so in the second quarter, somewhat more so in the third, and almost stationary in the last quarter of the first year of life, after which it proceeds *pari passu* with the general growth of the body.

A point on which much misapprehension exists is the frequency with which the infant should be fed. At first the intervals should not be greater than 1½ to 2 hours, but after the second month these periods should be extended to 3 or 4. It is true that the stomach is generally empty at the end of 2 or 2½ hours, and the infant, if accustomed to be fed at that time, will by force of habit cry for more; but the observations of two German physicians, Drs. Keller and Czerny, of the Children's Hospital at Breslau, who determined the state of the contents of the stomach by drawing off samples by means of flexible india-rubber tubes at frequent intervals, showed that though empty the stomach is not then ready to resume its function, another 1¼ hour or thereabouts elapsing before the secretion of hydrochloric acid again commences. In short, the stomach, like every other organ, requires a period of rest before resuming its physiological function, the termination of which is indicated by the reappearance of the secretion of the acid, the mucus having meanwhile been neutral and the digestive function suspended. The results

of introducing more food as soon as the last meal is disposed of are either to keep the stomach full of food that it is unable to digest, and which undergoes abnormal fermentative changes, or to exhaust it by stimulating it to renewed action before it has had time to recuperate. If an infant be accustomed to wait three or four hours, or even longer when sleeping, it will soon acquire the habit and the digestion will be more healthy and complete.

Cream is a substance of very uncertain composition, differing from milk only in containing a much higher proportion of fat. The various percentages are given elsewhere, and it will be sufficient to observe here that its use as an article of food is of service when the state of health or nutrition indicates the expediency of giving an additional amount of fat, which is here presented in a more palatable form than in cod liver oil, and when other fats are not relished or are ill assimilated.

Clotted, called also Devonshire or Cornish cream, owes its distinctive characters to the prolonged heating to which it is subjected. The percentage of fat, 50 to 60, is a little higher than that in thick cream, but that of the solids not fat is 6 to 12, averaging 7, or about double that in milk or cream, in consequence of the loss of water by evaporation during the prolonged heating.

Junkets, and the German *sauer Milch*, consist of curds and whey, the coagulation of the casein in the former being effected by the addition of rennet, and in the latter spontaneously, *i.e.*, by the action of certain bacteria with the formation of a small proportion of lactic acid. It requires great care in its preparation, with perfect cleanliness and a uniform temperature, otherwise butyric acid and other objectionable fermentations may occur. Fresh drawn milk is put into jars with wooden covers, which are kept in a cool cellar and inspected from time to time. Two or three days are required in warm weather and a week in cold; the result being a uniform soft coagulum, the separation between the

curd and whey scarcely perceptible, and the sourness such only as gives an agreeable refreshing flavour, which is enhanced by the addition of white sugar and a little grated cinnamon. Any neglect of the precautions indicated is followed by the formation of hard or stringy curds, and a disagreeable degree of sourness, which renders it repulsive to a refined taste.

Koumiss and *Kephir* will be considered in the chapter on the Therapeutics of Milk, these preparations being in Europe chiefly used in the dietetic treatment of disease.

Milk Foods.—Besides the countless farinaceous preparations professing to have been subjected to various degrees of cooking or malting, and intended as adjuncts to a milk diet, there are a number of so-called malted milk foods in which milk already enters in a dried state. They may be good enough as an item in the dietary of invalids, but cannot be recommended for infants, since starchy and farinaceous matters are present in great excess, and in the process of desiccation the distinctive properties of the milk are to a large extent altered or lost.

CHAPTER X

THERAPEUTICS OF MILK

The Dietetic Use of Milk in Disease.—From the time of Hippocrates, who advised the consumptive to drink every morning a large quart jugfull, *τρικότυλον κύλικα*, of asses' milk "if he could," milk as nature's sole diet for the young of all mammalia has been looked on as the one perfect food, all-sufficient in itself, especially for old age, indeed as a sort of elixir of life.

But a consideration of its chemical composition and physical properties is enough to show that this is only partially true, and that it is as unsuited for some cases as it is invaluable in others. It is a highly albuminous food, with a large amount of water, and consequently tending to increase and accelerate the metabolic processes; and since rapid growth and repair involve, *pari passu*, the removal of the pre-existing tissues and effete material, milk is specially adapted to the periods of infancy and early childhood in health, and to all ages in convalescence from diseases attended by great emaciation, and calling for the restoration of the wasted muscles and fat. In such cases, as in infancy, it may be taken *ad libitum*, if it can be digested, for the gastric secretion may be unequal to the peptonising of the coagula of casein, which give rise to discomfort or actual pain, and may undergo fermentation or putrefaction in the stomach and intestine with evolution of gases and even the formation of toxic products.

The popular notion that milk as the food of infancy is calculated to rejuvenate old age is based on an utter misapprehension. The composition that renders it appropriate

for the period of life, or the conditions in which tissue change and regeneration are proceeding with great rapidity, unfits it as the sole or principal article of diet for that age in which these are almost in abeyance; but as a part of the mixed dietary it is very useful when mastication is defective and the digestive powers are feeble, as a substitute for the more solid forms of albumen, as meat, for the proper digestion of which previous mastication is indispensable. Milk, however, it must be borne in mind, is not strictly a liquid food, since it undergoes separation in the stomach into a coagulum of great density and a whey which still contains over 7 per cent. of solids. The composition of curds is variable, but those obtained by means of rennet consist on an average of water 49.4, casein 19.7, fat 27.5, sugar 2.28, and ash 1.12 per cent. When the coagulation is effected by acidulation and boiling it is different, the water amounting to 68.0 per cent. and the other constituents being from the mean of different analyses, casein 21.0, fat 5.0, sugar 4.0, and ash 2.0 per cent. Those formed in the stomach probably resemble rather the former or rennet curd, the proportions of water and solids being almost identical with those in cooked meat. While, as milk, it does not admit of mastication, the dense masses of curd may offer to the action of the gastric juice difficulties scarcely less than those presented by like pieces of meat, and comminution being out of the question it is advisable, when any difficulty is felt in its digestion in a pure state, to minimise the bulk and density of the curd by diluting the milk with water, or mucilaginous or starchy solutions as gruel, barley water, &c., or to give it in the form of bread and milk. Dilution is preferable in fevers and illness generally, and the addition of bread in health.

From the frequency with which portions of undigested curd appear in the fæces we infer that the digestion of the casein is to a great extent performed in the intestine and by the proteolytic ferment of the pancreas, since any pepsin that passes the pylorus with the curd is immediately pre-

cipitated and rendered inert by the alkaline reaction of the contents of the bowel, and it follows from this that it cannot but be imperfectly performed in inflammatory, catarrhal, or atonic conditions of the intestinal tract.

A milk diet is indicated (1) when a light, nutritious, non-irritating food is required, the digestive functions being normal though more or less enfeebled by the previous disease, as in convalescence in general, anæmia, phthisis, &c.; (2) when ulceration of the stomach or intestine renders solid foods a source of pain or danger, and (3) in diabetes mellitus or glycosuria, in which all starchy foods and sugars other than lactose are contra-indicated, and the appetite palls under an exclusive diet of butcher's meat and fat.

In convalescence from fevers and wasting diseases, and in anæmia, phthisis, &c., milk is given along with other foods, and its use calls for no special remarks. In enteric fever it has long been the practice to restrict the patient to a diet of milk alone, and it is often a very satisfactory course. But it is not unfrequently found that the bowel has, in consequence of the ulceration of the Peyerian and intestinal glands, and the accompanying inflammatory process, lost its power of digesting the curds, which undergo putrefactive changes accompanied by the evolution of gases, and absorption of septic matters, aggravating the tympanitis and the tendency to diarrhœa, and causing an increase of the pyrexia. On the appearance of these symptoms it should be at once discontinued, the bowel cleared of the curds by a dose of castor oil, followed by one of laudanum, and strong broths, and farinaceous and mucilaginous fluids substituted until all signs of intestinal irritation have passed; any milk that may be subsequently given tentatively having been peptonised so that the formation of coagula in the stomach and bowel may be prevented.

In ulcer of the stomach milk is as a rule borne remarkably well; not only do the coagula not irritate the ulcers, but they appear to relieve the pain, probably by neutralising the acid

of the gastric secretion and protecting the ulcerated surfaces therefrom; for it is often found that the pain is far more intense when the stomach is empty and the gastric juice begins to pour out, than when food is present. In fact the pain is rather of chemical than mechanical causation, and that such is the case is shown by the instant relief that follows the administration of a large dose of carbonate of soda. Should, however, the milk be ill borne it should be peptonised and rendered distinctly alkaline with sodium bicarbonate. In colitis, especially the simple primary ulcerative form, milk should be the main article of food. In diarrhœa, as a rule, a milk diet with or without the addition of farinaceous foods, is appropriate; but there are cases, even among young children, in which the diarrhœa being caused by the ptomaines formed by bacteria for which milk presents the best pabulum, a cure is impossible save by withholding milk altogether for some days, until the offending bacteria have been starved out.

Persons returning from India with chronic diarrhœa, resisting every form of medical treatment, will rapidly improve when kept on an exclusive milk diet; and though they should as a rule be confined to bed meanwhile, they will be sometimes able to go about, and in rare instances are found even to gain flesh. In the so-called hill diarrhœa, sprue, or, as Dr. Thin has called it, psilosis, the patient should be restricted to milk alone, and the same applies to many cases of dysentery in which no addition whatever to the milk can be tolerated.

The value of milk in typhoid fever may depend not merely on its nutritious and digestible nature, but, as Sir Lauder Brunton suggests, on the aid to the elimination of effete matters afforded by the quantity of water ingested in this form, and this doubtless applies even more strongly to the "whey cures," and the use of skimmed and butter milks.

These are all useful in renal diseases in which the eliminatory function of the kidneys is impaired, or the tubes are

choked with degenerated epithelium and the débris of cells and casts; when the mere imbibition of fluid, increasing intravascular pressure, favour the removal of the obstruction by simple mechanical flushing.

In diabetes and other forms of glycosuria, diseases in which the power possessed in health of completely oxidising amylaceous and saccharine foods is lost, all sugar ingested or formed in the body, with the single exception of milk sugar, passes out in the urine as a form of glucose. In these milk may, with advantage, be given in large quantities in conjunction with meat and fat, or even as the sole nutriment in the case of those who have a relish for it, and by whom it is well digested. This is especially successful in cases of glycosuria associated with gout, and presenting evidence of contracted kidneys. In cases of gouty kidneys with no sugar, but traces of albumen and low specific gravity, an exclusively milk diet is a great aid to elimination, and may avert the attacks of spasmodic dyspnœa and even of uræmic symptoms.

Peptonised Milk.—When through extreme atony of the stomach, through ulceration or other disease of that organ, the natural power of peptonising the casein is lost, the change may with advantage be brought about in the milk itself by the addition of some solid or liquid preparation of pepsin, or of the mixed enzymes of the stomach and pancreas of one of the lower animals, that of the pig being the most active. The milk is diluted with an equal volume of hot water, the ferment added as directed for the particular preparation, and after being well mixed the vessel is put to stand for about twenty minutes in another containing hot water, so that its temperature may be maintained at 99° F., or that of the living body. If left longer it acquires a bitter taste, and at the end of an hour would be absolutely undrinkable. Since this indicates that within the first half-hour the conversion of the casein into pepsin has only commenced, it is clear that the practice of bringing it to the boiling-point, thus

destroying the enzyme and arresting the further process is erroneous. The milk should rather be prepared in small quantities at a time, and the whole drunk before it has become unpalatable, so that the artificial digestion may be continued in the stomach. If the milk must be kept the vessel containing it should be immersed in ice, which will have the effect of suspending the peptonisation without destroying the ferment, the action of which will be resumed in the stomach. It should, however, in most cases, that is unless iced drinks are indicated, be warmed for a few minutes before being administered. In rectal feeding, where the question of taste does not enter, the artificial peptonisation may with advantage be carried on for an hour before the injection.

The use of peptonised milk in infant feeding is to be strongly condemned, except under such circumstances of disease, &c., as render it advisable in the case of adults.

Milk and **Whey Cures** were practised by the Arabian physicians, but in recent times have been revived and systematised by the Russian, Dr. Karrick, in the treatment of many chronic diseases, and have found advocates in Karel, F. von Niemeyer, Winternitz, Pécholier, and Weir Mitchell, who all attach great importance to the method of applying them as regards the quantities and times of administration. Karel excluded all other foods, especially at the commencement of the treatment, beginning with a teacupful of warm milk at 8 A.M., 12, 4 P.M. and 8 P.M., and gradually increasing the quantity taken at each meal to three cups. Constipation in the earlier stage of the course he regarded as an indication of tolerance, and remediable by an enema or mild aperient, but if persistent calling for the addition of coffee to the first meal, and of stewed fruit or roast apples to that at 4 P.M. Diarrhœa and flatulence he met by reducing the quantity or substituting skimmed for whole milk, and, after five or six weeks, allowing a more mixed diet, preferably light bread and pounded raw beef, reducing the meals of

milk alone to three, and, later, giving milk gruel instead of milk only.

The diseases in which Karel found it most successful were dropsies, whether of renal or cardiac origin, hyperæmia of the liver, neuralgia, especially if dependent on abdominal disease, hysteria, and especially obstinate dyspepsias. Even in advanced disease of the heart, kidneys, or liver, relief was obtained in the diminution of the dropsy, but no benefit was found in cases of advanced tuberculosis.

Weir Mitchell began with much smaller doses, not more than one tablespoonful, and that of skimmed milk, every two hours, the doses increased by one tablespoonful each, until by the third day the daily allowance was 16 ounces. In the course of the second week, larger quantities were given at longer intervals, and whole milk gradually substituted for skimmed; after the third week, a little white bread, arrow-root or rice was added; in the fifth, one or two cutlets daily; and after the sixth, the patient passed to a mixed diet, though for a long time milk formed a large item. Weir Mitchell never observed any gain of weight at the commencement of the course, and, indeed, very fat persons would continue to lose weight even when the consumption of milk was at its maximum.

Lebert obtained very favourable results from a milk cure in ulceration and other grave disorders of the stomach, but he strongly deprecated the rigid milk and whey cures in all other diseases, except some forms of diabetes. He prefers giving large quantities of milk along with a mixed nutritious and digestible dietary, recommending the patient to drink slowly 300-500 grammes, or half a pint to a pint of milk, where practicable freshly drawn and warm from the cow, every morning and evening between 5 and 6 o'clock. At the same time he allowed a dinner of soup, roast meat, young vegetables and cooked fruit, with a little wine or beer. An hour after the morning's milk, a breakfast of tea or coffee with milk and biscuits, and perhaps one or two lightly

boiled eggs, and in the evening a supper of good soup with, in the absence of fever, some more roast meat. If milk were well borne, he would add another 100/200 grammes (3-6 ounces) of milk to the breakfast and supper.

Whey is never given, as milk is, without other food, but in large quantities it acts as a laxative and diuretic, partly, as H. May thinks, in virtue of the salts, especially those of potash, to which he ascribes also its occasional effect on the heart, temporarily increasing the force and frequency of the pulse.

KOUMISS OR KUMYSS

Kouniss, obtained by the alcoholic fermentation of milk, has been in use among the nomad tribes of Western Asia from time immemorial. Homer ("Iliad" xiii., 6, 6) called the Scythians Galactophagi, or feeders on milk, and Hippomorgi, or milkers of mares, and Herodotus (iv. 2) describes their method of churning the mare's milk in wooden tubs; but neither of these authors alludes to its fermentation or the intoxicating character of the product, so that it seems probable that koumiss as we know it was a discovery of later date. Be this as it may, it is certain that it has been known to the Bashkirs and the neighbouring tribes for many generations, perhaps for centuries; but though it was frequently mentioned by the Russian medical men practising in Orenburg, Samara and Astrakhan, and Spassky in 1834, and Flamenko in 1842, contributed papers on its therapeutic uses to the Russian *Military Medical Journal*, it was not until the publication of the works of Ukke in 1863 and of Poloubensky in 1865 that the attention of physicians in Central and Western Europe was turned to the subject. About that time a number of monographs appeared in Russian, but that by Stahlberg of St. Petersburg (1869), published in German, did most to popularise the subject beyond the limits of the Russian Empire. The fullest account of the preparation of koumiss from the milk

of cows as well as of mares, and of its therapeutic uses, with a review of the literature in English, will be found in the appendix by Dr Stange to Bauer's "Dietary of the Sick and Dietetic Methods of Treatment," being vol. i. of Ziemssen's "General Therapeutics," translated by the present author, and published by Smith and Elder in 1885.

Koumiss is a white foaming liquid, with a refreshing, slightly acid taste, containing small but variable quantities of alcohol, the percentage depending on the mode of preparation and the time that it has been kept in process of fermentation.

The preparation of koumiss by the nomads of the Steppes is a somewhat rude and empirical process, carried out in a manner, and amid surroundings, far short of Western standards of cleanliness, with the result that the product, though palatable while fresh, is very unstable, undergoing speedy decomposition.

The Steppe mares, whose udders have been remarkably developed by ages of selective breeding, and which are kept solely for this purpose, are milked six to eight times a day, the quantity yielded at each milking being about one litre.

The milk is poured into "sabies," the oriental leathern bottle, made of a smoked horse hide, or into long narrow cylindrical wooden churns or mere earthen jars, each being fitted with a suitable stirring rod or mixer. The ferment, consisting of koumiss of one, two or three days old according as a weak, medium, or strong product is desired, is added in the proportion of one part to ten of the fresh milk. The mixture is continually stirred and agitated during the day, but allowed to rest at night. The temperature should not be under 55° F., and the higher it is (up to 95°) the more rapidly the fermentation proceeds. At the beginning of the season, dried residue of the previous year's koumiss is used as a ferment, or, if none be available, an artificial one is made by mixing wheat flour, millet, honey and brewers' yeast with stale mare's milk to a paste, which is tied up in a calico bag

and dropped into the milk. In about twenty-four hours the fermentation will be proceeding actively, and the koumiss ready for bottling.

For the nomad tribes on the Volga and Ural koumiss is a food rather than a medicine, though available for a few months only in each year. During the long and severe winter they and their herds are reduced to the verge of starvation; but with the return of spring the rich sweet pasture of the Steppes restores flesh to the herds and flocks, while the tribesmen revel on fat mutton and koumiss, of which they consume enormous quantities. But so long as its preparation was held to be a secret of the tribes, the obstacles in the way of its use as a restorative in wasting diseases were insuperable. The remoteness of the region and the difficulty of communication save with a few of the neighbouring provinces of Russia, the dirt and hardship of a life in the "kibitkas" and huts of the natives, at one time deemed an essential of the cure, but unendurable by any save the seasoned traveller, and the cost and unsatisfactory character of the accommodation in the hotels and "establishments," with very few exceptions, effectually deterred medical men from advising their patients to resort to Samara or Orenburg as they would to the Engadine or to Egypt. The clear dry atmosphere of the Steppes in summer, where the humidity does not exceed 55°, is doubtless, like that of deserts and elevated plateaus generally, a great aid in the treatment of tubercular and other cases. There are certain peculiarities in the composition of the milk of the Steppe mares, which are ascribed by Postnikof, of Samara to the pasturage, an opinion with which other local physicians and the proprietors of "establishments" agree; whereas Stahlberg of St. Petersburg refers them to the breed, which he maintains need not degenerate through removal to other climates, provided the conditions be not too diverse. But though this difficulty were overcome, and the uncertainty attaching to the alcoholic strength and acidity, with extreme instability of the

koumiss prepared by the crude and empirical method of the nomads removed by the adoption of more exact and scientific processes and greater cleanliness, the comparatively short period in each year during which the mare is in milk effectually precluded the systematic employment of the koumiss cure in chronic tubercular and other diseases. Poloubensky was the first to prepare koumiss from cow's milk, which he skimmed in order to assimilate it to that of the mare. His procedure was to pour into an oaken cask a bottle of five days' koumiss as a ferment, with a glass of warm water, in which thirteen grammes of milk sugar had been dissolved, and a bottle of skimmed milk. The mixture was beaten for half an hour, then after three hours' rest a second bottle of skimmed milk, and after three more a third, the half-hour's beating being repeated each time. At the end of forty-eight hours the koumiss was ready for bottling, and put by for two or three days according to the strength desired; but after four days it was unusable except as a ferment.

He was satisfied that this koumiss was much more digestible than the original milk, and that its action on the nutritive processes was in every respect the same as that of mare's milk, which was almost unobtainable in winter.

Koumiss of a more stable character is now made at several of the great dairy companies' works in London and abroad. To Dr. Vieth belongs the credit of having first prepared from cow's milk a koumiss of known and constant composition, and of such stability that it could be kept for weeks, thus permitting its delivery at a distance by rail.

The details of the procedures followed by the several companies are trade secrets, jealously guarded from their rivals and the public, but they all consist essentially in the observance of the utmost cleanliness, the sterilisation of all apparatus employed, and perhaps of the milk itself, so as to exclude all bacteria that might set up irregular fermentations; the removal of a portion of the fat and the addition of some milk sugar; and the greatest care in the preparation of the special ferment, which should approach as nearly as possible

to a pure culture of the specific organisms necessary for the production of alcoholic fermentation, that the bacteria ordinarily present in the milk and derived from the air are incapable of effecting.

Dr. Paul Vieth, whose procedure was based on that of Dr. Jagielski, not only studied the methods practised in Russia, but took advantage of the presence of a herd of Steppe mares with their Bashkir attendants at the Health Exhibition held in London in 1884, to prepare koumiss in England from mare's milk, and to employ it as a standard in his experiments with cow's milk. His cow's milk koumiss received the highest commendation from Russian physicians and competent judges, who pronounced it in no way inferior to the genuine article, over which it possessed the advantage of far greater stability. Messrs. Welford and Sons, Ltd., of Elgin Avenue, Maida Vale, prepare a cow's milk koumiss fully equal to that of Dr. Vieth, and apparently identical with those described on page 164 as "full" and "medium," but their analyses are not public. This is, however, a matter of little importance, since the composition of all undergoes changes, progressive though slow. The only essential difference is in the percentage of alcohol, which does not approach that in mare's milk koumiss until fermentation has been kept up for over three weeks, and never equals it. This is a difference which, for some therapeutic and dietetic purposes, constitutes a real defect, and which it is to be wished could be overcome. The following analyses of the Russian koumiss taken from Dr. Stange's work, of that made from mare's milk by Dr. Vieth in 1884, and of the different kinds prepared from cow's milk taken from Mr. Richmond's work, exhibit these differences very clearly and illustrate the changes effected in the several constituents of the milk by fermentation as well as the different rates at which the changes proceed in each.

From the first table by Dr. Stange it will be seen that by about the end of the first day the destruction of the sugar is complete; the alcohol and lactic acid, having attained their

maxima, remain stationary, the only changes recognisable after the thirtieth hour being an increase of the free carbonic dioxide and a reduction in the amount of proteids, due, as Dochmann showed, to the partial peptonisation of the casein and albumen, which are converted into parapeptone and peptone respectively.

DR. STANGE'S ANALYSIS OF KOUMISS FROM THE MILK OF MARES, PREPARED ON THE STEPPES

	Fresh mare's milk	Koumiss after 6 hours fermentation	Koumiss after 18 hours' fermentation	Koumiss after 30 hours' fermentation	Koumiss after 4 days' fermentation.
Alcohol	0 00	1 85	1.95	3.00	3 00
Carbon dioxide	0.00	0 38	0 60	0 70	1.10
Lactic acid	0 00	0 39	0 56	0 64	0.64
Milk sugar	5.10	1.88	1.63	0.00	0.00
Casein and albumen	2 30	2 25	2 20	2.00	1.60
Fat	1 90	1.90	1 90	1 90	1 90
Salts	0.50	0.45	0.45	0 40	0.40

The diminution in the percentage of salts is not easy of explanation. If not an error of observation it is probably due to the breaking up of the citrates, which, according to Soldner, constitute 33.07 per cent. of the total salts, and the conversion of the citric acid into carbon dioxide, which continues to increase after the alcoholic fermentation has ceased through the exhaustion of the sugar.

ANALYSES OF KOUMISS PREPARED BY DR. VEITH'S PROCESS FROM THE MILK OF STEPPE MARES IN LONDON

	After 1 day.	After 8 days.	After 22 days.
Water	91 43	92.12	92 07
Alcohol	2.67	2.93	2.98
Lactic acid	0.77	1.08	1.24
Milk sugar	1.63	0.50	0.28
Casein	0.77	0.85	0.88
Albumen	0.25	0.27	0.24
Albumoses	0.98	0.76	0.77
Fat	1 16	1.12	1.30
Ash	0.35	0.35	0.35

	Full Koumiss.			Medium Koumiss.			Whey Koumiss.			Diabetic Koumiss.			* "Russian Koumiss."		
	1 day	8 days.	22 days.	1 day.	8 days.	22 days.	1 day	8 days	22 days.	1 day	8 days	22 days.	y	a s.	22 days
Water	88 90	90.35	90.57	87.55	88.39	88.62	89.74	90.63	91.07	92.24	92 38	92.55	91.87	92.26	92.52
Alcohol	15	.94	1.04	29	97	1 05	.30	1 03	1.38	.28	35	.57	22	.45	57
Fat	1'35	1.36	1.38	1.54	1.56	1.58	.14	.13	15	57.	.52	.51	.34	33	.33
Casein	2 01	1.96	1.88	1.46	1.40	1.30	.15	.14	11	2 19	2 13	2.05	2.32	2.17	2.03
Albumin	.30	.23	.20	.43	25	14	.39	.36	.32	30	.25	18	.08	.07	07
Albumoses	.34	.53	.77	.48	.76	.97	.44	.49	.58	36	.48	65	32	.48	.63
Lactic acid	.34	.96	1.40	.68	1 20	1.67	.60	.91	1.26	.75	.86	1.22	.06	31	56
Milk sugar	6.03	3.10	2 18	6 80	4.70	3.90	7.48	5.52	4.34	2 78	2 42	1.64	3 95	3 08	2.45
Ash soluble	.17	23	23	.28	.32	.33	.37	.37	.37	.22	.24	.26	46	49	.49
,, insoluble	.41	34	35	.49	.45	.44	.42	.42	.42	.37	.37	.37	.38	1.36	.35

* This made from skimmed milk is no longer supplied.

Wiley gives the mean composition of Koumiss made in America as—

Water	89 32	Proteid	2 56
CO^2	.83	Sugar (milk)	4.38
Alcohol	76	Fat	2 05
Lactic acid	.47		

Comparing these with Stange's analysis we note, besides the slower fermentation, that the destruction of the sugar was not complete even so late as the twenty-second day, when consequently the percentage of alcohol had not quite reached the possible maximum which it did in the koumiss examined by Dr. Stange on the Steppes. Dr. Vieth did not estimate the CO_2 evolved in the fermentation, but distinguished the several proteids. The apparent fluctuations in the percentages of some of the constituents would be accounted for if, as is probable, the successive samples were not taken from the same milk as those of Dr. Stange's certainly were, and the same may be assumed of the following analyses by Dr Vieth of different kinds of koumiss prepared by him from cow's milk, and with one exception still supplied from the laboratory:

Kephir is a preparation of a similar nature, obtained by means of a different ferment, known as kephir grains. The following analyses are given by different authorities:

	König (mean)	Hammarsten	Vieth (... old sample)
Water	91.21	88.915	90.09
Alcohol	.75	.720	64
Lactic Acid	1.02	.727	.44
Fat	1.44	3.088	1 82
Sugar	2.41	2.685	1.87
Casein	2.83	2.904	2.90
Albumin	36	.186	.07
Albumoses	.30	.067	.05
Ash	.68	708	—

The amount of fat given by Hammarsten is remarkable.

When the fame of the "koumiss cure" first reached Central and Western Europe, its results were, like those of other cures, overrated by the exponents of the treatment, mostly medical practitioners interested in, if not themselves the proprietors of, "establishments" and "institutes" for carrying it out. Those who had set up in Samara and Orenburg availed themselves of the glamour attaching to the

Far East, the clear dry atmosphere, the sweet-scented pastures, and the wild life of the boundless Steppes, to represent these as indispensable conditions; while such, as circumstances detained at Moscow or St. Petersburg maintained that, suitable as those regions would be for sanatoria for consumption if they were more accessible and civilised, the treatment might be pursued with equal success in any healthy locality where genuine koumiss and pure fresh air could be had. The use of cow's milk rendering a supply of koumiss equally available throughout the year and the introduction of more stable forms have led to a much wider use and a more critical estimate of its value. The pioneers of koumiss taking the famished Tatar as an example, compelled their patients to swallow enormous quantities, ten litres or more in the day, and little else except fat mutton in the way of food or drink; but at present it is rarely that one is asked to exceed five litres, and a reasonable variety of foods is permitted.

It is now allowed by all that koumiss is not a drug, but a nutritive, digestible food and drink, although containing no very considerable amount of dry solids compared with the fluids. It is, in short, appropriate to the same class of cases as milk, over which it has the advantage of the greater digestibility of its partially-peptonised proteids, the presence of a small quantity of alcohol, and the refreshing effervescence. Combined with the open-air treatment it has been found to give excellent results in tuberculosis of every kind, in convalescence after wasting diseases and nervous exhaustion. The older writers not only enjoined a very restricted diet, but enumerated many diseases in which it was contra-indicated. At present the diet is regulated entirely by the disease and the patient's general condition, the koumiss being looked on merely as an extra or addition; and there are few diseases in which it would be deemed hurtful, unless some forms of heart disease, epistaxis, hæmoptysis, dysentery and diarrhœa, though in enteric fever Sambrzchitsky obtained the best results.

CHAPTER XI

THE RELATION BETWEEN MILK AND DISEASE

When one considers how many diseases have already been proved, whilst others are suspected of being, of bacterial origin, and that milk is one of the best of culture media, especially for the pathogenic forms, and is very prone to changes of a putrefactive and fermentive nature, with the production of ptomaines or poisonous alkaloids, and lastly that, quite apart from such specific infection or fermentation, the secretion is influenced in various ways beyond the power of the microscope or analysis to determine, as by febrile disturbance, disorders of nutrition, including the excretory functions, and even by mental emotion, one can not wonder at its being often unwholesome, or even poisonous under certain conditions, and a frequent vehicle of specific disease.

Apart from the ordinary souring of milk, and the putrefactive changes, set up by the *Bacillus coli communis* and other saprophytic bacteria, a remarkable phenomenon has been observed in milk when subject to the agitation of transport in hot weather, without having been previously refrigerated, in the production, doubtless by bacterial agency, of a ptomaine giving rise to vomiting, purging and prostration which, in a classical instance, occurring at a hotel in New York and investigated by Professor Victor Vaughan, was isolated and found to be identical with that which he had previously obtained from some poisonous cheeses, and he had accordingly called Tyrotoxin. He consequently came to the conclusion that it had not, as he then supposed, been

formed in the cheese, but was already present in the milk from which the cheese had been made.

Milk is more or less unwholesome when taken from a cow suffering from any febrile disturbance, inflammatory affection, or from fatigue, fright, or over driving.

Fermenting fodder, as brewers' and distillers' grains, silage or sour mashes, render the milk apt to sour early, and, even before it has undergone any perceptible alteration, to induce diarrhœa in infants; and such food is prohibited in the contracts made with the farmers by the better class of dairy companies, condensed milk factories and creameries.

Specific diseases communicable by milk include (1) diseases common to the cow and to man; (2) those primarily of the cow but communicable to man; and (3) those of man (*a*) under certain conditions, communicable in a more or less modified form to the cow, and (*b*) diseases peculiar to man, of which the milk contaminated by the addition of water containing the bacilli, by the hands of the milkers or by exposure to the infection in sick rooms, becomes the vehicle.

Of specific diseases common to the cow and man, communicable by milk, the most important, and indeed the only undoubted example is **tuberculosis.** Diseases of the cow communicable to man are **foot and mouth disease,** without any modification of characters, also **anthrax, pleuro-pneumonia,** and some others, both general and local.

The only disease of man that has been proved to be communicable to the cow, and retransmitted to human beings by the milk of the affected cow, is **scarlatina**; but those of which milk is the passive vehicle only are the most numerous, including at any rate **scarlatina, diphtheria, enteric (typhoid) fever,** and possibly **cholera.**

Many attempts have recently been made to revive the belief in the non-identity of human and bovine **tuberculosis,** and thus to impugn the soundness of the statistical evidence in favour of an increase in the intestinal tuberculosis of infants, concurrently with a reduction in every other form of

the disease at all ages, and assumed to be connected with their larger consumption of milk in its natural state; but it cannot be said that they have been successful. Formerly the dualists took their stand on the different appearance presented to the naked eye by "the grapes," or "Perlsucht" (*i.e.*, pearl disease) of the Germans, in the cow and of tubercular pleurisy in the human subject, but in 1901 Koch, who had been the first to isolate the bacillus and to demonstrate the real nature of tuberculosis, appealed to a series of experiments carried out by him and, as he said, confirmed by those of others in America. He failed to induce tuberculosis in a number of cattle, either by inoculation with cultures of the bacilli, or by adding to their food, for several weeks consecutively, tuberculous matter or tissues from human subjects; yet these, or similar animals, proved very susceptible to infection by like means when bovine instead of human tubercle was used. So, too, in animals of other kinds—rodents, monkeys, &c., the bovine was always more virulent than the human tubercle.

But admitting that his experiments on cattle were conducted with the utmost care to ensure success, it cannot be denied that in other hands, equally worthy of confidence, similar experiments have been completely successful. Under any circumstances negative results prove little, but when they are opposed by positive they simply indicate the presence of some factors, conditions, or circumstances, known or unknown, conspiring to defeat the result. The converse experiment of the intentional inoculation of man with bovine tubercle was, of course, inadmissible, although it alone could give an answer to the question of man's susceptibility to infection from the cow; but several instances are on record of infection following accidental inoculations under circumstances differing little, if at all, from those of scientific experiments.

It is well known that pathogenic bacilli acquire or lose virulence during cultivation in different media or in the

bodies of different species of animals, and, all that Koch's experiments show is that the bacillus of tubercle possesses, or acquires in the bovine organism an intensified virulence, well seen in the case of other animals, as monkeys, inoculated with it; and if so, why not in man? He proves too much for his own purpose, for while he has not disproved the susceptibility of man to bovine tubercle, he has even suggested that it may be more virulent to him than is his own.

Again, he endeavoured to refute the hypothesis of infection through the ingestion of tuberculous milk by arguing that in such cases the mesenteric glands must necessarily be the primary seat of the disease; whereas, frequent as is this form of tuberculosis in infancy as compared with adult life, it is rarely a primary condition, the lungs and other organs being also and probably already involved. This reasoning, however plausible, is not conclusive, for the evidence of the communicability of tuberculosis by the ingestion of tuberculous milk is in the case of rodents overwhelming, and in that of calves has been established beyond dispute, so that we are not justified in saying more than that the intestinal canal is not a favourable inlet, still less does it present a favourable nidus for the tubercle bacillus, which, if it gain access by that channel, appears in the majority of cases to be carried by the lacteals, the thoracic duct and the veins to other organs, as the brain or lungs, where the conditions are most favourable to their development, the intestinal glands becoming implicated later, when the general vitality has been impaired.

In short, the essential identity of the tubercle bacillus and tubercular disease in the cow, in man, and in other animals is indisputable, as is its communicability by means of infected milk among other modes and vehicles; and, lastly, experiments seem to indicate a greater virulence in the bacilli of the bovine disease alike to animals of the same and of other species, including man himself.

The transmissibility of bovine tuberculosis to man both by ingestion of tuberculous milk and by inoculation has been

demonstrated again and again by experience, having the force of experiment. One of the best known and most convincing is that reported by Dr. Ollivier, a story of thirteen girls, scholars of Les Dames Blanches at Chartres, of healthy parentage, and all previously enjoying good health, who, after having been some years in the school, fell ill in rapid succession, five of them dying of acute tubercular disease. Dr. Ollivier, suspecting the milk, had the cow kept on the premises slaughtered, when well-marked tubercle of the udder was found. Dr. Nocard also reports the case of the daughter of a medical man at Berne, a remarkably fine girl, who with her parents was in the habit of spending every Sunday at a farm-house. She died of intestinal tuberculosis primary and extensive, and four of the five cows belonging to the farm were found to have tubercle of the udder. Similar, though perhaps less striking cases have been reported by Johne, Demme, Stang, Leonhardt and Schuppenhauer, among others; and Mazyek Revenel, of the Sanitary Board of Pennsylvania, in 1900 described five instances of tuberculosis of the skin produced by accidental inoculation in men, four of them veterinary surgeons, through wounds contracted in cutting up the carcases of tuberculous cattle. Every one no doubt has often drunk the milk of cows suffering from tuberculosis of the udder, but only the more susceptible have contracted the disease; though Kunth and Ostertag, experimenting on guinea-pigs, found that the quantity drunk was an important factor in the infection, and very few, except infants, take habitually large quantities of milk as such.

As to the proportion of cows whose milk contains the bacilli we have a considerable number of observations. Professor Sheridan Delépine, at Manchester, found tubercle bacilli in 16 of 432 samples of milk taken from dairies in the city and under sanitary supervision, the proportion being only 3.7 per cent.; but in 16 of 91 samples of country milk, and in 17 of 93 taken at the railway stations, equal to 17 per cent. and 18

per cent. respectively; more recently, he has found the proportion to be 25 per cent., and Dr. E. Hope at Liverpool found them in 7 of 24 samples, or 28 per cent. Hamilton, Boyce, Woodhead and Delépine, in their observations at Liverpool, found the proportion to be 29 per cent. Böllinger at Munich found 16.6 per cent., Martin in Paris 33 per cent., Bang in Copenhagen 15.5 per cent., the Municipal Laboratory at Paris, 40 per cent., Peters in Boston, U.S.A., 33 per cent., Fiorentini in Milan, 10 per cent., and Obermeier in Berlin, where the inspection of dairy farms is practised, only 7.5 per cent. Obermüller, however, found 8 out of 13 samples from one large dairy in Berlin infected, and Jäger 7 out of 100 consecutive samples delivered to a hospital in Königsberg.

Attempts have been made, notably by Koch himself, to invalidate the conclusions of the late Sir R. Thorne-Thorne, from the increase of intestinal tuberculosis in infants of late years, while every other form of the disease has diminished remarkably at all ages, on the ground that were such increase due to the more general use of cow's milk, the intestinal disease would be in most cases primary, instead of being usually secondary to deposits in other organs. But Nocard's experiments with the bacilli of glanders proved beyond question that infections by no means necessarily manifest themselves at the point of inoculation or entrance, and thus tubercle bacilli taken in through the villi of the stomach and bowel may pass on and find a lodgment in other organs where the conditions for their development are more favourable. Yet primary intestinal tuberculosis, though not of frequent occurrence in infancy, is infinitely rarer in adults. German medical literature, with its *Centralblätter*, rarely misses any observation of interest in that of other countries, yet Behrens could find but two such cases down to the year 1894; and though others have been added since, as that noted by Ollivier from Berne, they are so few as to be practically unknown. On the other hand, Böltz found eleven cases of the primary disease in 176 post-mortem

examinations of children with intestinal tubercle. Gravitz, between 1876 and 1888, at the Charité Hospital at Berlin, found 10 primary and 20 secondary cases, and Biedert only 16 of exclusively intestinal tubercle among 3104 children dying of tubercular affections. These, few as they may be, are numerous indeed when compared with the cases occurring in adults, and are, moreover, only those in which the intestinal disease existed alone, or greatly in advance of the few deposits in other organs, and probably represent but a minority of those originating in the bowel; for when tubercle was, as it is in most fatal cases, widely disseminated, it being impossible to say with certainty which was the original focus, the cases were assumed to be secondary as regards the bowel, though it was quite as likely that that was the primary seat, and the pulmonary disease secondary thereto.

There is no doubt that during the last fifty years bovine tuberculosis has increased enormously, especially among cows; and during the same period the mortality in England from abdominal tuberculosis of infants under one year has also increased by 27 per cent.. 4278 males and 3754 females of 1,000,000 children born dying from this cause within the first year, mostly between three and six months from birth. In the second year the mortality falls to one half of that in the first year, and from this time sinks rapidly.

The prevalence of tuberculosis among cattle may be estimated by the numbers reacting to the tuberculin test, or by the presence of tubercle visible to the naked eye, but the figures available, for the most part, include oxen, who, from their more natural and out-door life, are far less liable to this disease than dairy cows. Confining our attention to the latter, we learn from Mr. C. Hunting, F.R.C.V.S., that 25 per cent. of those in London and 40 per cent. in Edinburgh reacted, the average in Yorkshire, Durham and Midlothian, having been about 25 per cent. In the German slaughter-houses about 35 per cent. of the cows presented some evidence of tubercle, the proportion rising with the age to

99 per cent. These figures include the most trivial deposits, as in the bronchial glands, though, of course, in the majority the disease would have extended in course of time.

But the only conditions certainly rendering the milk a source of danger, especially to infants and invalids, whose powers of resistance to infection are least, are cases in which the udders are actually involved, and these are fortunately but a small minority. Thus in Prussia and Saxony, of the cows recognised as tuberculous after slaughter in the years 1891 to 1897, only 1.35 were found to have tuberculous udders, but Prof. Osterta believes that in *generalised* tuberculosis the udders are implicated in from 5 to 10 per cent. of the cases.

Taking dairy cows collectively, Prof. Stockman found that, among 300 examined there were 6, or 2 per cent., with tuberculous udders, but Messrs. Young and Walker, of Aberdeen, found 8 out of 77, or 10 per cent. These figures, coupled with the irresistible evidence of the fact that tuberculous milk may be, and is, a means of communicating the disease, should convince the most incredulous that the danger is real and great.

Foot and Mouth Disease has been proved to be communicable to man through drinking the milk of affected animals. Prof. Johne tells how in a district in Germany where the disease was prevalent, the occurrence of numerous cases of "pneumonia" accompanied by eczematous or herpetic eruptions, and occasionally fatal to young infants, attracted his attention, and in Eulenburg's *Handbuch des Gesundheitswesens* he relates how two young medical men and a veterinary student each drank a litre of milk from infected cows daily, until on the fourth or fifth day they were attacked with febrile disturbance, pulmonary catarrh, and eczema of the face, hands, and feet. The same milk when boiled was found to have been rendered harmless.

Of the diseases of man communicable to the cow, and by her to man again, one only is at present known, viz.,

scarlatina. Our knowledge of the subject dates from the classical investigation by Sir W. H. Power, Medical Officer to the Local Government Board, assisted by Dr. Klein and the late Dr. Cameron, Medical Officer of Health of Hendon, into a widespread epidemic of scarlatina in Marylebone, St. Pancras, and Hampstead, in the year 1885, and practically confined to the customers of a particular dairy farm at Hendon. The farm had been for several years regularly inspected by Dr. Cameron, the water-supply was taken from the mains of the West Middlesex Company, the sanitary arrangements of the sheds, and those for dealing with the milk, scalding and steaming the pails, and the supervision of the persons employed as well as for the reporting of cases of infectious diseases not only in their families, but in those of other persons in the neighbourhood unconnected with the farm were practically perfect. Yet at a time when there were no cases of scarlatina on or near the farm the disease broke out simultaneously in four separate localities in St. Pancras and Marylebone, and about a fortnight later in Hampstead, while in the two former districts there was an intermission, a period of ten days, during which no fresh cases appeared; and after the sale of the milk had been prohibited, and the epidemic was abating everywhere, some of it was clandestinely given away to poor families in Hendon with the result that it appeared simultaneously in about half a dozen separate households, and disappeared so soon as this irregularity was detected and stopped. It was evident that the milk was the sole and direct source of the infection, the only question was as to how the milk itself became infected in the ascertained absence of any cases of scarlatina in the neighbourhood of the farm. Further inquiry revealed the fact that the whole or nearly the whole of the cows had suffered during the period in question from an ailment attended by some febrile disturbance, so slight, however, as not to sensibly affect their appetites or yield of milk, but manifested by a peculiar vesicular or pustular eruption on

the udders, leading to ulcers which formed scabs that subsequently dried and fell off. The disease was introduced by two cows bought in the market and added to the herd a week prior to the first appearance of scarlatina among the customers, and by two others purchased a fortnight later. It was evidently highly contagious, nearly every cow in those sheds being attacked. The third shed, the milk from which was distributed in Hampstead, remained free until, a few days before it was decided to stop the sale, some of the affected cows were removed thither, with the result that scarlatina broke out in that district also. Dr. Klein then took up the inquiry, inoculating cows and calves with the discharge from some recent ulcers, or with subcultures of the micrococci obtained therefrom, producing in each instance a disease identical in every respect with that of the original cows. They suffered from albuminuria, and the kidneys exhibited anatomical changes identical with those in the human kidney after scarlatina. The discharge from the ulcers and the blood swarmed with streptococci indistinguishable from those of scarlatina. Cultures of these inoculated into rodents and other animals or mixed with their food produced in them symptoms identical with those caused by cultures of the streptococci of scarlatina. In fact, the demonstration was complete of the pathological identity of the Hendon disease with scarlatina, even to the unintentional experimentation on the children of the dairyman's customers, the infection of the Hendon disease inducing scarlatina in them, and that of scarlatina causing the same phenomena as did the Hendon disease in calves, and lastly, the effects of the two on other animals were indistinguishable as were the appearances of the microbes themselves. Since that time several other outbreaks of scarlatina have been traced to milk supplies from dairies in which the cows were found to be suffering from the same eruption on the udders, and no other source of infection could be discovered in cases of scarlatina among the persons connected with the farm or with the distribution of the milk.

But by far the larger number of outbreaks of scarlatina and of diphtheria traceable to milk-supplies arises from direct contamination of the milk, either by the milkers or from the presence of cases of these diseases in the families of the milk vendors, especially when the parents of the patients serve in the shops handling their children and the milk by turns, though these cases will in future be checked by universal compulsory notification.

Enteric Fever (Typhoid) is also spread by milk, though probably always through the addition of specifically contaminated water. There is at present no evidence of the susceptibility of the cow to enteric fever, though as a large drinker of water, often highly polluted, her opportunities for contracting the disease are such that if she were susceptible she could scarcely escape. In every outbreak that has been investigated since the classical case of Cattermole's Dairy, Islington, in 1870, reported by the late Dr. E. Ballard, the supply of water for dairy purposes has been taken from a well communicating with and polluted by an adjacent cess-pit, by leakage, overflow, rat holes or percolation, or in a few instances exposed to the inflow of storm and surface waters, while in a very large proportion there have been cases of enteric fever in the farm-house or among the persons employed in the dairy, sometimes unrecognised, sometimes wilfully concealed, by which the milk may have been directly infected, and through whose excreta the well has been polluted.

The pretext of the dairyman is, of course, that the water was not added for fraudulent purposes, but merely used for washing the pails and "churns," though when, as is frequently done, the rinsings of the pails are added to the milk it becomes only a question of quantity. Still, considering the rapid multiplication of bacteria in milk, it becomes conceivable that those present in the few drops of water left in the pail might suffice to contaminate the entire volume of milk.

CHAPTER XII

THE DAIRY

THE extent and equipment of the dairy depend on the character of the work carried on therein. The minimum requirements being those of the farmer who sends his milk every morning and evening by road or rail direct to London or other large towns, mostly consigned to certain regular customers, either dairy companies or private firms, wholesale dealers with whom he contracts to supply a fixed amount according to the time of year; any excess being often sold openly at the terminus as "accommodation milk" to such of the wholesale traders as may want more than their ordinary supply, or to small dealers who depend entirely on this casual source, which is always available.

The maximum is that of the country gentleman's establishment, where the daily consumption of cream and butter as well as of milk by a large household and the dependants is provided for on the premises, any surplus being sent to market or to tradesmen in the nearest town; and that of the dairy farmer, in the full meaning of the word, who sells not only milk, but cream and butter, or lays himself out chiefly for butter manufacture.

The first needs only a room for cooling the milk as it is brought in by the milkers, and measuring it out into the churns, and another for washing the empty churns if that has not been done with better appliances by his customers; whereas the latter must have other rooms for storing, for the separator and the churning, working and making up of the butter, and a boiler for steaming the churns and cleaning of all the utensils employed in these processes.

The first essentials of a dairy, large or small, are that it shall be clean, cool, and airy; and where milk is stored and cream and butter are made, that the temperature shall be uniform, and under complete control at all times of the year, viz., 50° F. to 55° F.

For this purpose it is desirable that it should be so far as possible sheltered by buildings and perhaps also by trees from the direct rays of the sun. The walls should be substantially built, and the windows restricted to the north and north-east aspects, but of ample size and opening to at least half their extent. In the small dairies used simply for receiving the milk, refrigerating and straining and sending it off to the railway station, perfect cleanliness, the light necessary to ensure this, and free ventilation, with the exclusion of sunshine, insects, and dust, are all that are required. But in larger and more complete establishments, which are in constant use for storage, creaming, and butter-making, much care must be given to the details of construction.

Outer Walls.—The walls should be hollow, bonded at regular intervals, and the intervening air space ventilated above and below, affording protection against extremes of external heat and cold.

Windows.—For the same reason the windows should be double, with apertures for securing the ventilation of the interspace when they are closed. Perhaps the very best construction is that in which the outer consists of two sashes hinged to a (vertical) mullion, and opening outwards like doors; the inner of three sashes, of which the upper is hinged on its lower side to the (horizontal) transom, and let down by cord and pulleys, and the lower two fixed vertically to the mullion, and opening like the outer sashes, but inwards. There should also be a wire gauze screen fixed, like the outer sashes, to exclude dust and insects, while admitting air when the windows are open.

Roof.—There will, however, be little gained by the best

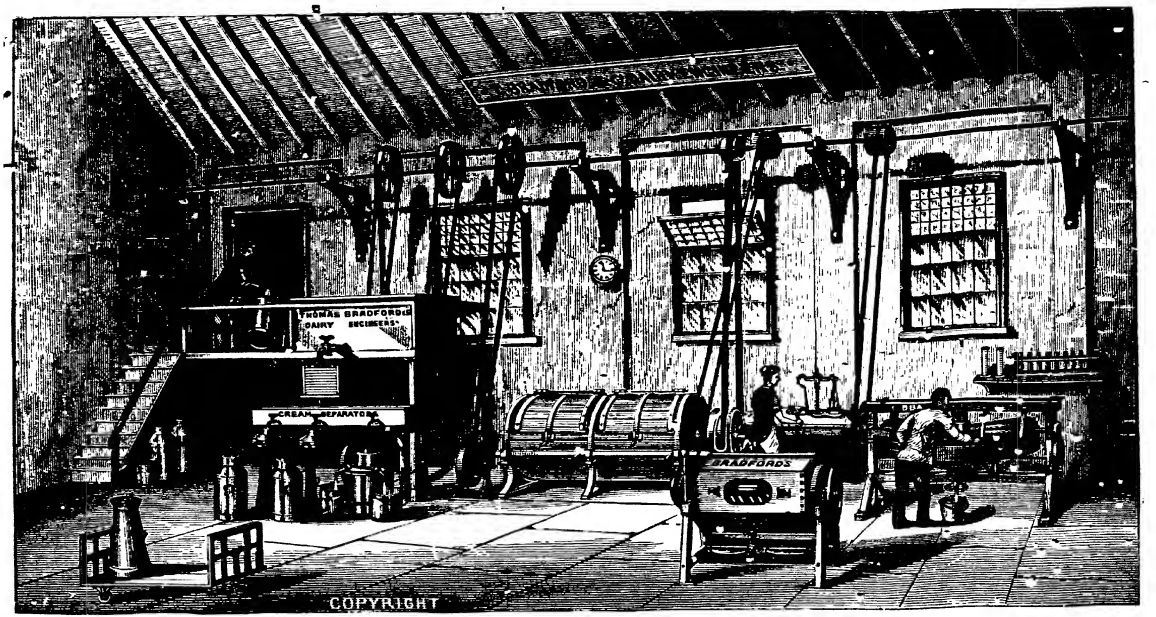


Fig. 20. MODEL DAIRY

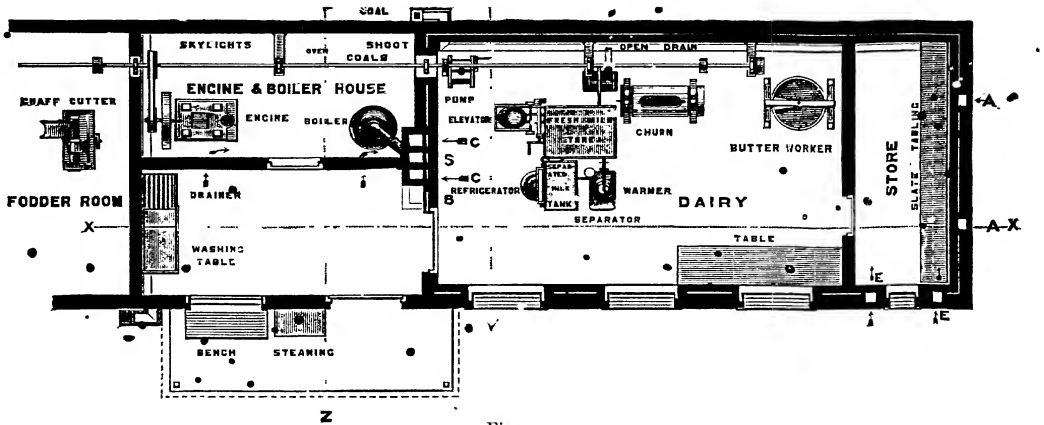

COAL
SKYLIGHTS
OVER
SHOOT
COALS
OPEN DRAIN
ENGINE & BOILER HOUSE
CHAFF CUTTER
ENGINE
BOILER
PUMP
ELEVATOR
C
S
C
CHURN
BUTTER WORKER
STORE
SLATE TABLING
A
A X
FODDER ROOM
DRAINER
REFRIGERATOR
WARMER
DAIRY
X
WASHING TABLE
SEPARATOR
TABLE
E
E
BENCH
STEAMING
Y
Z

Fig. 21.

position and construction of the windows if the sun's rays beat on the slant of a single roof. The entire building, or at any rate all rooms in which milk, cream, or butter are stored or dealt with in any way, should be ceiled, an ample space being left between the ceiling and the roof, and freely ventilated. With a high-pitched roof this space may take the form of a loft, the windows of which should be fitted with wooden or thick glass louvres, in place of sashes, so as to admit of a constant movement of the air. It might be used as a storeroom for spare pans and implements, but should never be allowed to degenerate into a lumber room.

Verandah.—The outer walls may with great advantage be further sheltered from the heat of the sun by a verandah carried round the building, the roof of which may be continuous with the slant of that of the building itself, in the smaller dairies attached to gentlemen's houses; or, especially in large establishments, independent of it, and, resting against the wall at the level of the ceiling. In the former it may be made to add to the picturesque appearance of the building, and in all it must, of course, be well paved. In such a verandah the empty churns should be stood after having been cleansed.

Cellar.—A cellar beneath the dairy may be utilised as an ice-house.

Wall surfaces.—In the rougher form of dairy it will be sufficient if the walls are lime-washed at regular intervals, but in the better class glazed porcelain tiles, or other impervious, non-absorbent and washable surface material, is in every way preferable.

Floor.—The floor should be at least six to twelve inches above the level of the ground, and should also be impervious and free from all inequalities, no material being so good as fine smooth concrete. Tiles are not to be recommended, since the spaces between them afford lodgment for spilt milk, providing a soil for the growth of bacteria, which, drying and floating in the air, may either by themselves or their spores

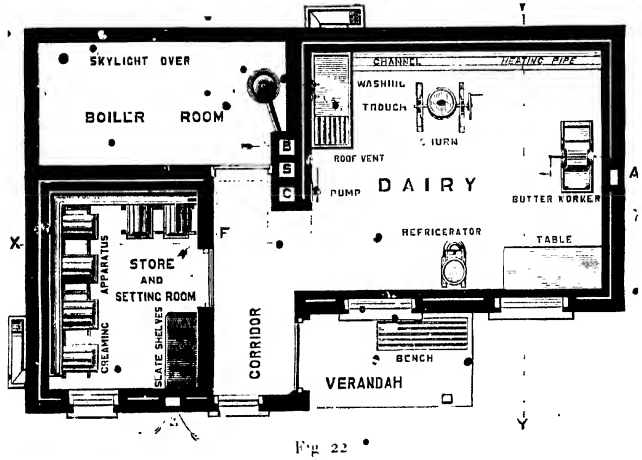


Fig. 22

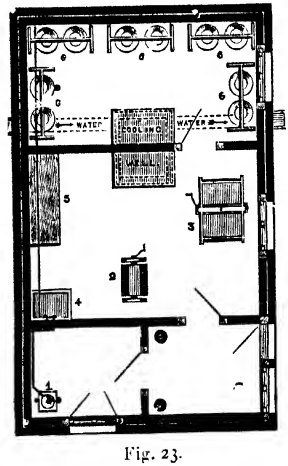


Fig. 23.

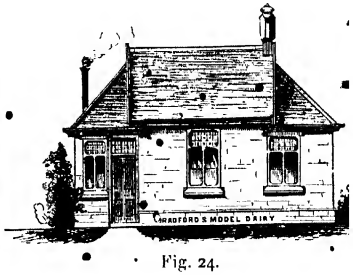


Fig. 24.

contaminate the milk standing in open vessels. The floor should be washed down daily, and the washings conveyed away by open gutters or channels of half pipes of glazed earthenware, not by grids or gulleys, into drains beneath, from which effluvia may enter, any such being outside the building.

Warming.—To maintain a temperature of 50° to 55° in cold weather, some form of artificial warming will be necessary. Open fires are not easily regulated, and since in a complete dairy there will be several rooms, and a boiler is required for scalding the churns and vessels, the warming is best effected by hot water or steam-pipes carried round the building from the adjoining boiler-room.

Rooms. In a complete dairy there should be (1) a room for utensils, (2) a boiler-room, (3) a larger one for the cooler, separator, churn, and butter-worker, and (4) another for storing milk and cream in open pans.

Water-supply.—A cistern into which water is pumped direct from a well, or laid on from a public service, should be fixed on the floor of the loft, or if there be none, near the ceiling of the machine-room (3), which is the coolest, but not so near as to render its inspection and occasional cleaning difficult; it should not be so large as not to be quickly emptied, and when supplied from a public service, the water should be admitted by a tap, not a ball valve or cock, otherwise the water will acquire by standing the temperature of the room; whereas a small cistern may be emptied and refilled with really cold water whenever the **refrigerator** is used for cooling the milk, which cannot be done at all satisfactorily if the temperature of the water is above 45° or 48° at the utmost.

Refrigerator, or Milk Cooler.—As the milk is brought in warm from the cow and within ten minutes of milking it should be strained through muslin and poured into a large vessel or tank fixed immediately above the refrigerator, down the surface of which it runs in a thin

cascade, while cold water traverses the channels in the interior of the apparatus from below upwards, the outgoing water which has abstracted the heat from the milk being conveyed away by a pipe or hose, and used for any other purpose, as feeding the boiler, washing utensils, or filling drinking-troughs in the yard. There are several patterns of refrigerator, but Lawrence's is without question the best. The effect of rapid chilling, if carried out within 5 to 15 minutes from its being taken from the cow, is to retard the souring by 12 to 36 hours, and is absolutely indispensable if the milk has to be sent any distance by road or rail, since without such preliminary treatment it would, after prolonged agitation, especially in hot weather, be sour, curdled, and unfit for consumption, if not actually poisonous, from the formation of an alkaloid known as tyrotoxin. Where ice is to be had the addition of some to the water in the cooler would be desirable in hot weather, and where steam-power is employed for working the separator an ice-making machine might be added providing a constant supply of this article for the table, as well as for keeping the butter cool and fresh.

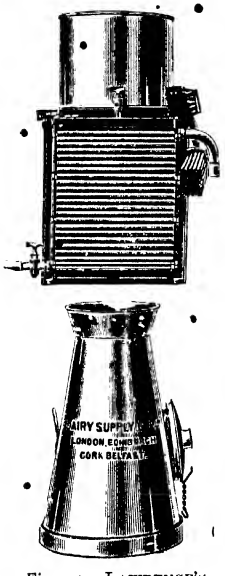


Fig. 25. LAWRENCE'S REFRIGERATOR With Milk Tank and Churn

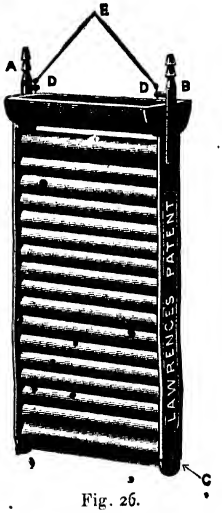


Fig. 26.

The **separator** is also indispensable in dairies where cream and butter are made, some form of this apparatus having almost everywhere superseded the primitive method of skimming off the cream that rises spontaneously. Not only is the cream much greater in volume, but it is thicker and richer, the fat being almost entirely removed, and the new process presents the further advantage that it is

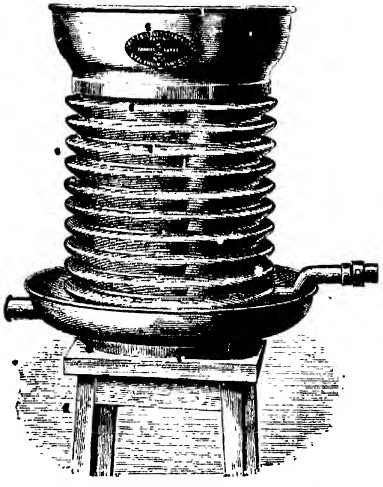


Fig. 27. CYLINDRICAL "LAVAL" COOLER
(May be used for warming also)

completed while the milk is still sweet and fresh, so that the separated milk, unlike skimmed milk, is free from the least trace of sourness, and provides a wholesome and agreeable drink.

The action of the separator or centrifugaliser is based on the fact that when a mobile mass composed of particles of different densities is made to rotate with great rapidity the heavier particles tend to fly outwards, the lighter remaining in the region of the axis. There are several patterns, but the principle of all is the same ; a cylindrical vessel, rotating at

the rate of 2000 to 7000 revolutions in the minute, into which the milk is run in a continuous stream, the lighter portion, or cream, being drawn off by a pipe dipping into the centre, and the heavier, or separated, milk consisting of the water, casein and sugar leaving by another pipe near the margin (Figs. 28, 29 and 30).

A still heavier and viscid portion, the separator slime consisting of particles of dirt, epithelial cells from the milk-ducts, mucus and pus cells, if any be present, together with bacteria, adheres to the walls of the vessel, and, remaining behind when the process is completed, is removed by cleansing.

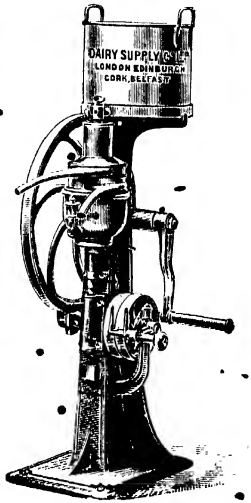


Fig. 28. FARMERS' "ALFA" LAVAL SEPARATOR For Smaller Dairies (10 to 30 Cows)

Closed separators, the cover of which is perforated for the passage of the feed-pipe only, as the Alexandra, deliver a cream slightly warmer, 1° F. to 2° F., than the milk. Open ones, as Burmeister and Wain's, with no cover, allow of a considerable cooling of the cream by the air-currents produced by the rapid movement to the extent of 10° to 15°, or even 20° F.; and the semi-closed, as the Alfas, the cover of which has an aperture large enough to permit of air being drawn in, will cool the cream by 4° to 6°. F.

There is, of course, no sharp line of demarcation between the cream and the milk, the density of the cream obtained depending on the zone from which it is taken. If a very thick cream, that is one containing the largest proportion of fat be wanted, it must be drawn from as near the centre as possible; and the friction due to its viscidity being great,

separators which discharge it through a simple aperture are preferable to those that do so through a pipe; but when the cream from its thickness amounts to no more than 6 per cent. of the volume of the milk, the quantity separated in a given time will probably not exceed half of that of thin cream that would be produced in the same time, and a larger

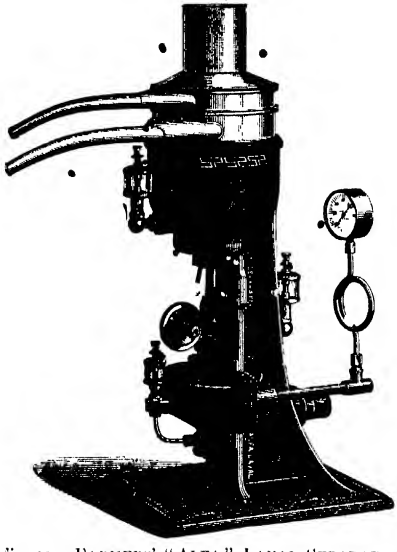


Fig. 29. FARMERS' "ALFA" LAVAL SEPARATOR
For Larger Dairies (30 to 60 Cows)

percentage of fat remains in the separated milk. But such thick cream is really seldom required, a thinner product, equalling in volume 10 to 12 per cent. of the original milk, is preferable for table use and for the butter dairy, since even it may need watering before it is churned; and though there may be more buttermilk to deal with afterwards, the very small proportion of fat left in the separated milk, and consequently the larger yield of butter, is a matter of greater importance. If the milk be warmed to 80° or 90° F. before

it is separated the fat may be removed to within 0.03 per cent.

Separators are now to be had of every size, from miniature apparatus, which, fixed on a table, will separate nine gallons in the hour, suitable for private families keeping one to three cows, up to larger machines capable of treating 100 or more gallons in the same time. The smaller are worked by hand, the larger by steam power, and these again by belting or by a turbine, the last being almost silent, and free from the risk of accidents incident to belting where women are employed. The "Alfa"-Laval, which is made of every size that can be wanted by families or farmers, is, without question, the very best; but there are others still larger, designed for use in factories where many hundreds of gallons of milk have to be dealt with daily.

Fig. 30. HAND-DRIVEN SEPARATOR
For Private Families
(1 to 6 Cows)

Cream Raising.—The slow and imperfect separation of the cream, when left to rise spontaneously under the old and now almost obsolete practice of allowing the milk to stand for a period of days in open pans, is owing to the peculiar behaviour of the fat globules, which vary not only in size but in other respects, some rising with comparative rapidity, others remaining stationary, and a few even tending to sink.

It had long been known that the cream rose more rapidly while the milk was being cooled down, and Swartz's method of accelerating the natural process by first warming the milk in pails, and then immersing them in cold or iced water, was in very general use in Germany and Denmark in the middle of the last century. The principle attained its highest application in the so-called Jersey Creamer, which is still in use in many dairies at the present time. It consists of a

shallow rectangular tank of tin plate, with double bottom and sides, with a draw-off pipe and tap beneath, a glass "window" in one side reaching to the bottom, and a lipped notch or weir in one side, the pan being so mounted as to admit of being gently inclined towards that side by raising the opposite.

After the pan has been filled with milk, hot water is run

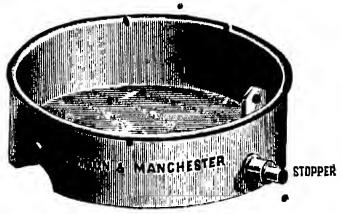


Fig. 31. Bradfords "Brittany" Porcelain Milk Pan

For "Skimming" Cream by Running-off the subjacent Milk

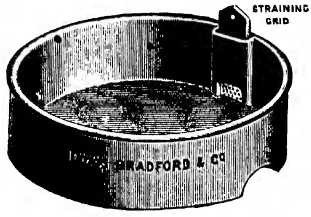


Fig. 32. "Brittany" Milk Pan

Another View

into the hollow space in the bottom and sides until the milk has attained a temperature of about 85° F. The hot water is then run off, and its place taken by the coldest water available, the effect of the rapid cooling of the milk being to greatly accelerate the rising of the cream, and to separate the cream more completely than it could be otherwise. The "skim milk" is then run off by the tap in the bottom of the pan, until it is seen through the "window" that only the cream remains, when the pan is tipped up and the cream

poured out over the lipped weir. The action of the Cooley and other creamers is essentially the same, and though not equal in rapidity or in completeness to centrifugalisation, is superior to the old plan of relying on the spontaneous rising of the cream consequent on incipient souring.

But, provided the most scrupulous cleanliness is observed in every detail, butter of the best quality can be made from the cream rising naturally in improved pans (Figs. 31 and 32), though, when any considerable portion of the cream is to be sold or used as such, some form of separator is indispensable. The sweet cream obtained by the separator is not suitable for churning, since a certain degree of souring is necessary for developing the aroma characteristic of a fine butter. Such cream, however, "ripens" if kept at a temperature within a few degrees of 60° F. for three or four days. Each day's cream may be kept separate or mixed with that of the preceding day, but not more than three consecutive days' milks should be mixed, and the whole must be well stirred before churning. If the cream be too fresh, the addition of 10 to 15 per cent. of sound buttermilk will improve the butter But the souring must not be allowed to proceed too far, or the volatile triglycerides will be destroyed and the butter will acquire a rank taste. Souring or ripening is only one of the many fermentations to which milk and cream are liable, all the effects of the entrance of bacteria of different kinds from without. The particular kind desired by the butter manufacturer, and that which causes coagulation without excessive sourness, as in the preparation of the German "sauer Milch," are present in the air of the dairy; those inducing putrefactive changes, rancidity, &c., are mostly introduced by dirt, the *B. coli communis*, with the dung adhering to the udder, others by the hands of the milkers, and so on, or are present in the stale or sour milk adhering to the surfaces of imperfectly cleansed vessels. Those requiring nitrogenous pabulum, as the casein in milk, are the most apt to give rise to offensive products, and it is

thus that butter insufficiently worked and washed from the milk is most prone to butyric fermentation or rancidity. The aroma of fine butter and the characteristic flavours of the different kinds of cheese are due to the products of special varieties of bacilli, which have recently been so far identified that the desired results, free from all disturbing influences, have been obtained by adding to previously Pasteurised or sterilised milk or cream pure artificial cultures of the particular species required.

Clotted or Devonshire cream is thicker and has a sweeter taste than that obtained in the ordinary way. After the milk has stood in the pans for twelve to twenty-four hours, it is placed over a slow fire until it shows commencing ebullition, when the pan is set aside to cool for eighteen to twenty-four hours. Milk so treated yields one-fourth more cream, of a consistence so dense as to be cut with a knife, owing doubtless to the coagulation of the albumens. Butter made from it partakes of its characteristic flavour, but from the presence of the nitrogenous constituents it does not keep well.

BUTTER-MAKING

When the cream of each day is kept apart, the "ripening" is more gradual and uniform than when those of successive days are mixed, when the sweet cream added is apt to be curdled by that which has already become acid. If, however, the quantity of cream obtained daily is so small that it cannot be conveniently treated separately, the several additions should be thoroughly incorporated by stirring.

There are innumerable forms of **churn** in the market, but they may all be referred to three or four classes, those rotating on their short axis (end over end), those rotating on their long axis, a few with a to-and-fro swinging movement (cot swing), and small domestic churns in which the cylinder does not move but the contents are agitated by an axial mixer not unlike the mechanical egg-beater.

The best of all is Bradford's end-over-end (Fig. 33), the speciality of which is the diaphragm or mixer, with which the large factory churn of the same firm (Fig. 34), rotating on its long axis, and driven by steam power, is also fitted; the diaphragm of very ingenious design being their own patent.

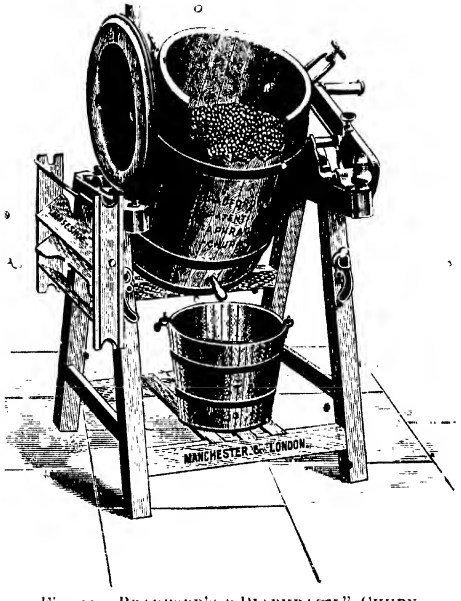


Fig. 33. Bradford's "Diaphragm" Churn

Their end-over-end churn, barrel-shaped, is worked by hand, the limbs of the handle being rectangular, and bearing in bold letters simple directions for their use (Figs. 38, *a* and *b*, p. 198).

The churn must never be allowed to become dirty or sour It should be well washed out after use with boiling water and again before using with hot and cold, or, as some advise, with hot water in winter and cold in summer. In summer the room should be as cool as possible, and in winter the temperature about 60°. The churning must be performed

without interruption or jerking, the speed gradually increasing at the beginning and slowing off towards the close of the operation, and the number of rotations per minute forty to

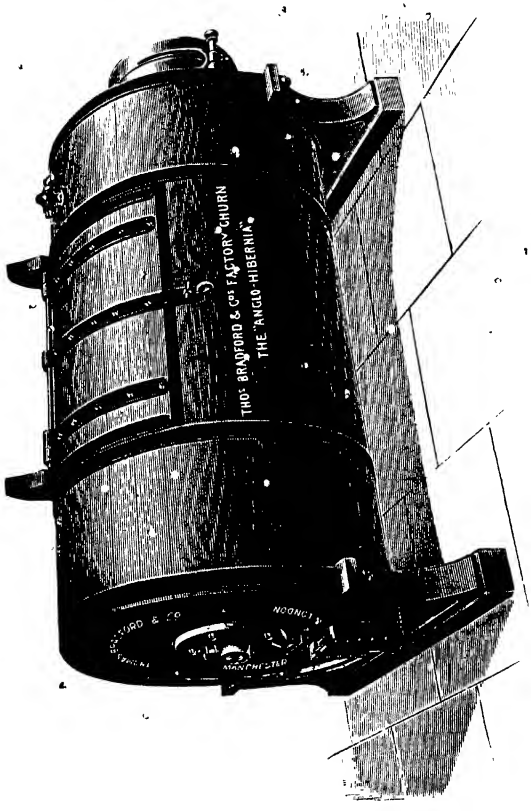


Fig. 34. Bradford's Factory Churn "Anglo-Hibernia"

fifty with churns rotating on the long axis, and sixty with the end-over-end patterns in the minute, until the butter "begins to come."

The Royal Agricultural Society has published some excellent rules for the conduct of the churning.

"Prepare churn, butter worker, wooden hands and sieve as follows:—

(1) Rinse with cold water.
(2) Scald with boiling water.
(3) Rub thoroughly with salt.
(4) Rinse with cold water.

"*Always use a correct thermometer*

"The cream, when in the churn, to be of a temperature of 56° to 58° *in summer*, and 60° to 62° *in winter*.

"The churn should never be more than half full.

"Churn at a number of revolutions suggested by the maker of the churn."

If none are given *churn at* 40 to 45 *revolutions per minute*. Always churn slowly at first.

"*Ventilate* the churn *freely* and frequently during churning, until no air rushes out when the vent is opened.

"*Stop churning immediately* the butter comes. This can be ascertained by the sound, if not, *look inside the churn*.

"The butter being now like grains of mustard seed, pour in a small quantity of cold water (one pint of water to two quarts of cream) to harden the grains, and give a few more turns to the churn *gently*.

"Draw off the buttermilk, giving plenty of time for draining. Use a straining cloth placed over a hair sieve so as to prevent any loss, and wash the butter in the churn with plenty of cold water, then draw off the water, repeating the process till it comes off quite clear.

"Make a strong brine (two to three lbs. of salt to one gallon of water) and pour it into the churn through a hair sieve. *Rock* the churn a few times before drawing off the brine, take the butter out of the churn, put it on the butter worker, and leave it for a few minutes to drain, then work gently until all moisture is pressed out.

"N.B.—*Never touch the butter with your hands.*"

Miss Maidment gives a regular scale for regulating the temperature of the cream inversely as that of the air.

Temp of Air, F	Temp of Cream, F.
66°	55°
64°	56°
62	57
60	58
58	59
55	60
50	61°

Every churn should have a vent-peg for letting out the gases and vapour evolved, and a pane of glass let into the

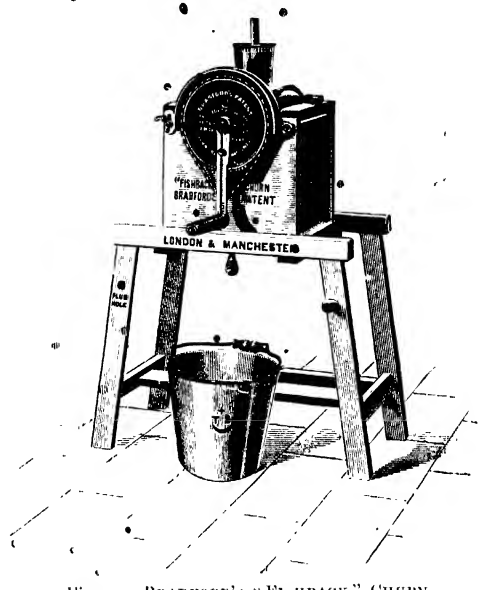


Fig. 35. BRADFORD'S "FISHBACK" CHURN

side that the state of the contents may be easily seen. So soon as the butter begins to form minute granules, the face of the glass, hitherto clouded, becomes comparatively clear. If the churning be prolonged another minute, the granules will have adhered and coalesced into larger masses, and it will be impossible either to wash the butter or to work out the buttermilk as it should be done, and the consequence is that

the butter, however tasty at the time, will soon turn rancid from the decomposition of the retained casein.

The aim of the washing being merely to remove the buttermilk is attained when the water comes out practically clear; but it is quite possible, by carrying it too far, to wash out the soluble glycerides, to which the flavour is due, leaving a stable but insipid product.

Fig. 36.

The "brining" above described is to be practised on all butter, fresh as well as salt, unless intended for immediate consumption, but the amount of salt must be guided by the demands of the market. In some parts of the country a fair proportion of salt is expected in all butter, whereas in London a nearly saltless butter is preferred. But though a *pure dry* butter will keep sweet for some considerable time without a grain of salt, the taste of the freshest is, like that of beef or mutton, improved by a little.

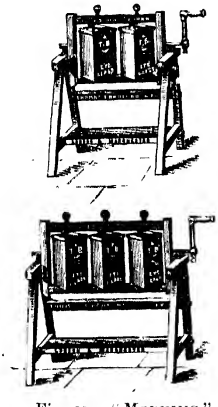


Fig. 37. "Morning" Miniature Churns For Family Use

In Holland the salt is added to the milk before churning instead of being worked in after the butter is made, and it was at one time the practice to dispense with skimming altogether, keeping each meal of milk apart in a cool place until enough had accumulated and the earlier meals were fully ripe, when they were all emptied into a large churn, and when the butter had come, the buttermilk was run off through a sieve into pails. This plan is still followed in parts of Ireland, but the souring is generally carried too far, and in Scotland the milk is sometimes poured into a large churn instead of being stood in pans, and left there for two or three days; when it has clotted or "lappered" it is

churned, and the butter so obtained is often of a high quality.

But the whole practice of making butter from milk instead of from cream is lazy and wasteful, the sour buttermilk being fit for pigs only; whereas separated milk, though less nutritious than the entire, through the removal of the fat, is a pleasant, wholesome, and nourishing drink, and is also quite as good as whole milk for use in puddings, &c.

Salt Butter, strictly so-called and prepared with a view to keeping, is made by incorporating $\frac{1}{8}$ to $\frac{1}{4}$ ounce of common

Fig. 38*a*. HANDLE OF "DIAPHRAGM" CHURN
One Side. The other has terse directions for use displayed on it

Fig. 38*b*.

salt in each pound of butter in the process of working. But Dr. Anderson recommends the substitution for common salt alone of a mixture of two parts of the best table salt with one of saltpetre and one of white sugar thoroughly powdered, mixed in a mortar, and kept in a tightly closed vessel in a dry place. One ounce of this is added to each pound of butter. The butter thus salted should be kept for two or three weeks before being used, or it will not taste well; but if carefully freed from every trace of buttermilk, it will remain in excellent condition for two, three or more years, and possess a sweeter, more agreeable flavour than is to be found in any salted in the usual way.

Before being packed in casks all butter should be made as dry as can be, a layer of dry salt pressed on to the bottom, each successive layer of butter moulded to that beneath, and another layer of dry salt pressed on the top before the head of the cask is put on. The absence of any shrinkage of the mass when the cask is opened will show if this has been properly carried out.

Working the Butter.—The purpose of this operation

Fig. 39 BRADFORD'S "MIDALBAN" BUTTER WORKER

is threefold—to press out the buttermilk, to incorporate the mass without destroying the grain, and to distribute the salt, if any, uniformly throughout. It may be effected by means of wooden hands when the quantity made is small, and is intended for immediate consumption. Otherwise some kind of mechanical worker is indispensable, doing the work far more quickly and thoroughly. These machines consist essentially of a fluted roller fixed on a table, by turning which first in one direction and then in the other, the masses of butter are pressed out into a sheet which is rolled and unrolled to and fro, while the expressed water and

butter-milk runs off in the channels made on its surface. To facilitate its removal the table is inclined (Fig. 39), or, better still, is made with an arched surface (Fig. 40), so that the water may run off freely in either direction, and the efficiency of the working is greatly increased by the substitution of a

Fig. 40. BRADFORD'S "ARCH ALBANY" BUTTER WORKER
Helicoidal Action and Double Drainage

continuous helicoidal fluting for the separate circular grooves of the older patterns. This is one of Messrs. Bradford's happy inventions, and one of which they hold the patent. For working butter on a large scale as in factories, and blending samples of qualities differing but little into perfect uniformity, a worker of a somewhat different kind is required. This consists of a circular table, over which a conical roller with deep longitudinal grooves is fixed, its base at the margin

and its apex at the centre of the table, and, its axis horizontal, at a distance equal to the semi-diameter or radius of its base above it. The roller and the table both rotate, increasing the rapidity with which the butter is worked, and in one pattern the roller extends the whole width of the table in the form of two cones, the apices of which meet in the centre (Fig. 42).

The Danish butter is the product of co-operative factories, owned by a number of farmers, who engage the services of a trained superintendent and a chemist. The milk sent in by each farmer is weighed, the percentage of fat ascertained, and the sender credited with the weight of fat calculated accordingly, until at the end of each quarter the profits are divided among the shareholders in proportion to the amounts of butter fat they have contributed. Uniformity of quality in the produce is secured by the mixing of the whole of the material and by the conduct of the manufacture being in the hands of one responsible manager.

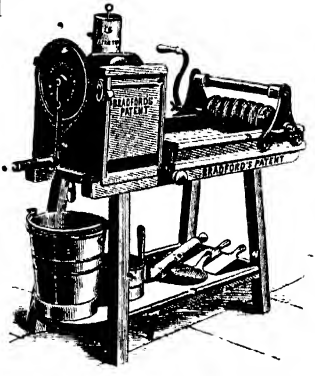


Fig. 41. BRADFORD'S "MIP" SMALL CHURN AND BUTTER WORKER COMBINED
For Family Use

But in the north of France butter blending is carried out on a larger scale. Buyers go round once or twice a week, purchasing in the markets from the peasants and farmers butters of the most diverse qualities. These samples are sorted and divided into three classes by their taste and appearance; and those of each class are worked together so as to obtain a uniform mass, which is then cut up into the desired sizes, and the qualities distinguished by black, blue and red marks on the cases in which they are packed.

Butter Workers are now as universally adopted in dairies for making up the butter as separators are for obtaining the cream, but the principle of centrifugalisation has been recently applied in an ingenious device, the Délaiteuse, as a substitute for the mechanical worker. It is a French patent, the agents for which in this country are the Dairy Supply Association. It seems to effect its purpose well, provided water is poured in to assist in washing out the buttermilk, and it is claimed for it by the inventors that a drier butter is produced than is possible by mechanical

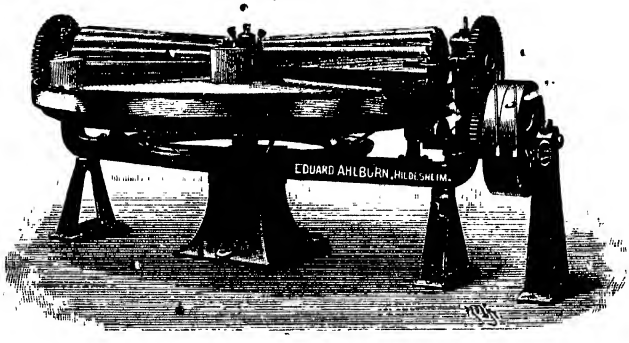


Fig. 42. AHLBORN'S REVOLVING BUTTER WORKER
For Factory Use

means. Bradford's Lily Dryer on a similar principle is equally if not more efficient (Fig. 43).

Though when butter is intended for immediate consumption the presence of a considerable amount of the buttermilk, as in the sweet hand-made butter of Devonshire, is no defect, and indeed is preferred by some persons, its complete removal is imperative in the case of butter that, whether fresh or salt, is to be kept for a shorter or longer time. So is that of the water with which the butter is washed before leaving the churn, but on different grounds. Butter fat, if absolutely pure, is very stable, as in the form of "Schmaltz," supplied to the crews of Danish and German shipping, a

pure, though insipid butter, obtained by melting the ordinary butter to the condition of oil, which, after the impurities have been removed by subsidence and skimming, is poured into casks, where it hardens as a homogeneous fatty mass, that with a very small addition of salt remains unchanged for an indefinite period. The rancidity that results from the retention of the buttermilk is due to the action of the decomposing casein and albumen on the volatile glycerides, butyrin and caproin, breaking them up and liberating the butyric and caproic acids, which are as offensive to the taste

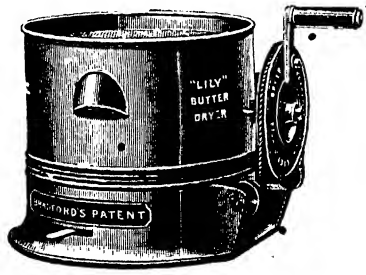


Fig. 43. "Lily" Butter Dryer

and smell as the respective glycerides are agreeable. Both these glycerides and acids, unlike the stearic, palmitic, and oleic, are soluble in water, and the insipidity of over-worked butter, as well as of "Schmaltz," is owing to the loss of the glycerides, while the process patented for the purification of rancid butter by melting, and the driving in of superheated steam, is based on the solubility of these acids in water.

The presence of water, as such, affects only the consistence of the butter, which is softer the larger the amount of water retained. This may be from ten to twenty per cent., or even more, though the Board of Agriculture has fixed sixteen per cent. as the permissible maximum, anything above this being deemed to be of the nature of adulteration. In

summer, when the temperature of the air tends to soften the fats, the removal of the water so far as possible is most desirable, but in winter it would be well to leave more, or the butter is apt to be inconveniently hard. The finer the granulation of the butter when taken from the churn the more difficult is the removal of the water, whereas the coarser granulation of over-churned milk tends to the retention of the buttermilk and casein.

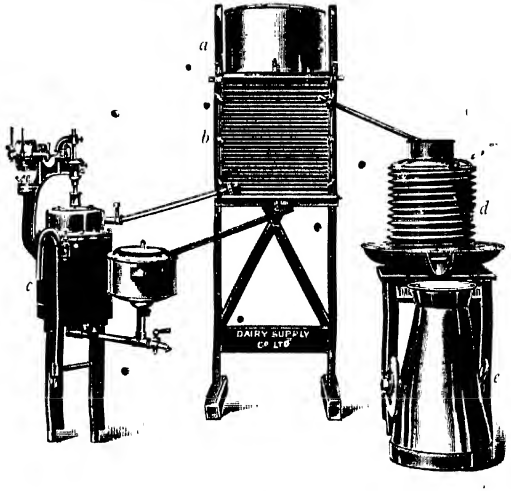


Fig. 44. Complete Pasteurising Plant
a, milk tank; *b*, "split" regenerative heater; *c*, Danish Pasteuriser; *d*, cylindrical Laval refrigerator; *e*, churn

The colour of natural butter ranges from a dead white to a golden yellow, depending on the feeding and on the breed. The brightest yellow is yielded by Jersey and Kerry cows, though that of all cows when out at grass in early summer has more colour than it has in winter. The popular prejudice in favour of colour has led to the practice of supplying the lack of it by artificial means, and so long as the perfectly harmless annatto is used there is nothing to be urged against

it. The best form in which it can be used is Nicholl's annatto in the proportion of one drachm in a pint of water to two to eight gallons of cream.

Accessory Apparatus.—Though milk can be satis-

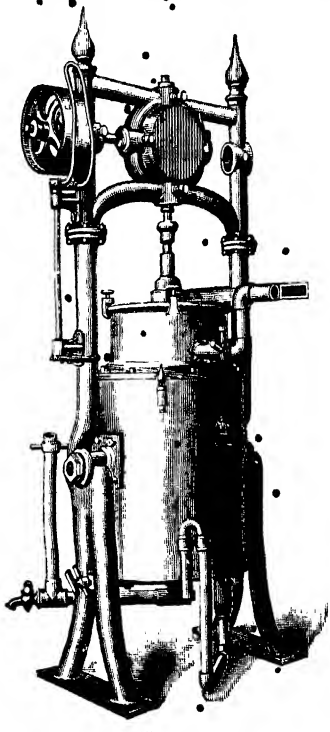


Fig. 45

factorily separated at any ordinary temperature the operation is best performed at 80°, 90°, or 95° F., and for this Bradford's Circular Heater or the "Economic" Danish Pasteuriser (Fig. 45), is the most convenient. It requires no pressure of steam, is fitted with a feed-regulator, and is made in different sizes

capable of raising 125 to 475 gallons of milk to a temperature of 95° F.

The Délaiteuse referred to on p. 202 is intended to supersede the butter-worker, but under the name of Butter Dryer Messrs. Bradford have designed a similar apparatus to complete by centrifugalisation the removal of the water begun by mechanical means (Fig. 36).

Milk Filters.—The sheet of muslin or similar material

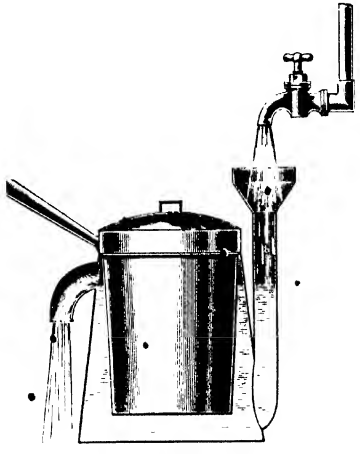


Fig. 46

stretched over the receiver or spread on a sieve, as used in all dairies, suffices for the removal of insects, hairs, road-dust, fragments of fodder, and the coarser impurities visible to the naked eye; but an examination of separator slime shows that besides matters derived from the glandular structures of the cow herself, a large quantity of dung and other dirt, apparently soluble, but really suspended in the form of particles of extreme fineness, passes through and remains in the milk.

Filtration through sand has for some time been extensively practised in Germany, and though the action of such filters

cannot be compared with that of the purification of water-supplies, the most important, indeed the essential factor in which is the living growth of green algæ, and other low forms of vegetable organisms on the surface of the filter, it cannot be denied that sand is the best material for the purpose. In the ruder forms first employed the advantages were almost if not more than counterbalanced by the difficulty

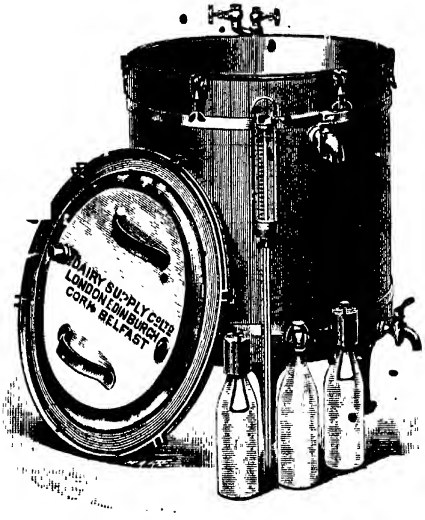


Fig. 47. "SIMPLEX" No. 1 STERILISER
Small Size, D.S.

of cleaning the sand, which, if not freed from every trace of stale milk, and especially of casein, would taint the subsequent charges of fresh milk. This, however, seems to have been quite overcome in Krohnke's Patent Gravel Filter, a drum-shaped vessel divided into three chambers, containing sand of as many sizes, through which the milk passes in succession. It is easily cleaned, *immediately after use*, by passing a stream of water through it in the opposite

direction, agitating the sand which fills the compartment by rotating the drum at the same time, until the water comes out clear and colourless.

But the mere mention of separator slime shows that the separator is the best purifier, and at Alfa-Laval, may be fitted with a special tin receptacle which, while it effects

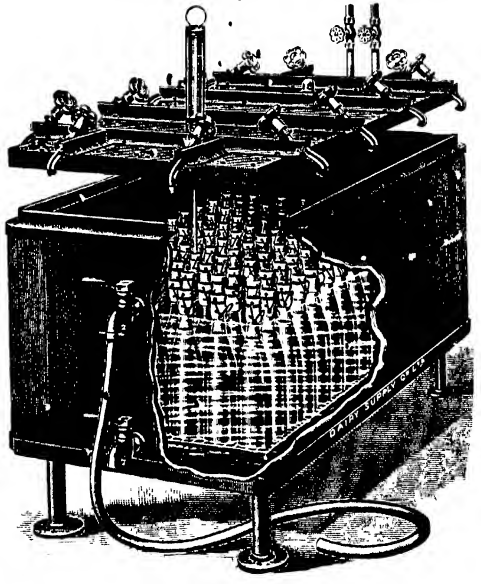


Fig. 48 "SIMPLEX" No. 2
Much larger than No. 1, D.S

the centrifugalisation and separation of the milk, retaining the slime only, remixes and discharges the whole of its contents through one spout.

Sterilisers.—Milk as it exists in, and leaves, the udder of a healthy cow is absolutely sterile, that is free from bacteria or micro-organisms of any kind, and if drawn with aseptic precautions into sterilised flasks, which are then hermetically sealed, or even closed with plugs of sterilised

cotton wool, it will remain for indefinite periods, (theoretically, indeed, for ever) without decomposing, souring, or change of any kind. But in the act of milking, and every moment subsequently, it receives from the udder of the cow, the hands of the milker, the surface of the vessels and the air itself, bacteria of every kind, which find in it the best of all

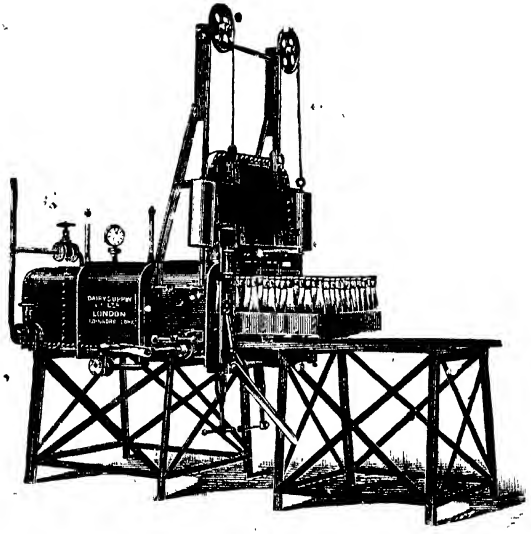


Fig 49

media, and multiply at a constantly accelerating rate, until in the course of a day there may be millions in a few drops. Some in the process of growth convert a portion of the milk sugar into lactic acid, just as yeast produces alcohol from the glucose in must, others break up the casein and induce putrefactive changes, and under certain circumstances pathogenic microbes or the germs of disease may find their way into the milk. Intermediate between these last and the former is *B. coli communis*, which, though ubiquitous, is

always derived originally from fæces, in this case cow dung, and induces sourness and changes of a mixed nature, and if in excessive numbers, may cause diarrhœa, especially in infants

Many years ago Pasteur called attention to the fact that twenty minutes' exposure to a temperature of 70° C. = 158° F. was sufficient to kill nearly all bacteria in the actively growing state; and this treatment is now in many dairies employed, under the name of Pasteurising, with the view of rendering the milk more stable, and by avoiding the irregular changes induced by *B. coli communis* and others to ensure a more perfect "ripening" of the cream for butter-making, the bacteria on which this change depends entering subsequently from the air of the dairy, or being introduced by adding some clean sour buttermilk or, though rarely, a pure culture of this particular species.

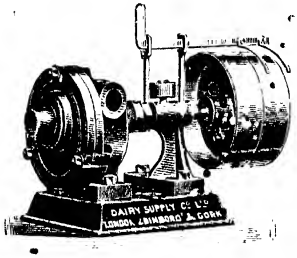


Fig. 50 DANISH ROTARY PUMP

But Pasteur soon found that the spores of such bacteria as produced them, pathogenic or disease germs being mostly sporiferous, were not destroyed, being resistant to all temperatures below the boiling-point; and he accordingly suggested repeating the process at intervals during which successive crops of spores had time to germinate, and, being then killed by the next heating, were at length exterminated. So long as this temperature was not exceeded, neither the taste, appearance, nor composition of the milk was altered in the least; but the procedure was far too tedious for practical

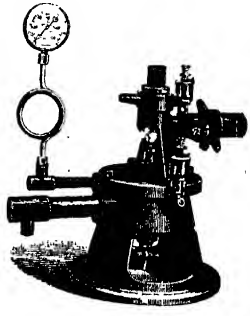


Fig. 51. ALFA-LAVAL STEAM TURBINE PUMP

use, and when it is desired to prepare a perfectly sterile milk to be bottled for keeping, or for infant feeding, it is found better to have resort, even at the cost of some small change in the character of the milk, to a temperature near or even above the boiling-point, thus at once destroying all spores as well as growing bacteria.

The terms Pasteurising and sterilising are somewhat loosely employed, but usually perhaps the former is applied to the treatment of milk in bulk, as in butter factories, and sterilising to that of milk bottled with a view to keeping it

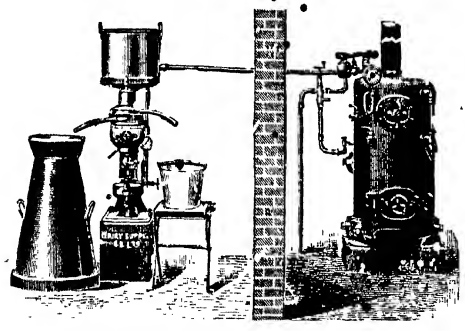


Fig. 52

unchanged for weeks or months. For the former procedure, in which absolute sterilisation is not essential, apparatus are employed constructed on much the same principles as the refrigerators, hot water or steam being substituted for the cold water.

For domestic purposes Aymard's so-called sterilisers are in great favour, and they are good enough for the nursery and family use when the milk is to be drunk within a few hours: they are simply double saucepans, such as are in common use for making porridge, and whenever direct contact of the sides of the vessel with the fire might lead to the burning of the contents. Messrs. Welford have produced a steriliser so constructed that the milk can, if desired, be rapidly

cooled down by running a stream of cold water from a tap through the jacketing by means of spout-like inlet and outlet (Fig. 46).

Sterilisers, strictly so-called, are of two kinds: (1) those like the Simplex (Fig. 48) or Lister's (Fig. 47), tanks of metal cased in wood, in which the bottles are immersed in water, or exposed to steam admitted by pipes at or a little above the boiling-point, a slight pressure being obtainable by the lid being screwed down; and (2) others, as Flaack's Sterilicon (Fig. 49), in which steam under a pressure of several atmospheres admits of temperatures being attained considerably over 250° F. Each has its advocates, who urge, in favour of the latter, the shorter exposure required, and, in favour of the former, the absence of perceptible alteration in colour and taste, which, however, it is alleged on the other side, does not occur under superheated steam unless the exposure is prolonged to an altogether needless period. In Flaack's Sterilicon the bottles are closed and run out on a sliding platform by the turning of a handle which lifts the side of the chamber as the bottles pass, closing it behind them. The attendants are thus not exposed to the steam, and the apparatus is ready to receive a fresh charge of bottles, very little, if any, heat having been lost in the change.

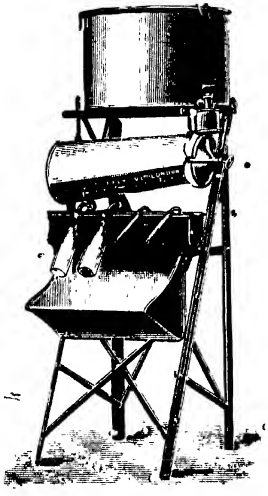


Fig. 53. "TWENGEN" BOTTLING MACHINE
Automatic Siphon Action

Other convenient accessory apparatus are pumps worked by belt-power (Fig. 50) or turbines (Fig. 51). The turbine presents several advantages over the belt where great power

is not required, on the score of compactness, safety, and economy of fuel. A turbine engine for working separators on any other machinery is shown at Fig. 52. Ice-making apparatus are almost a necessity in large factories and luxurious establishments, and, where sterilised milk is a feature in the business, a bottling machine (Fig. 53) is very convenient.

Frozen Milk.—The ice-making machine may be used also for freezing the milk itself, which is now supplied in the form of solid blocks of milk-ice to ocean liners provided with refrigerating chambers, in place of the sterilised and bottled, or the older condensed milks, sweetened or unsweetened, that it had to a great extent superseded, and one or other of which is still indispensable on board coasting vessels and yachts.

CHAPTER XIII

MILK ANALYSIS

Specific Gravity of Milk.—The specific gravity of a liquid is its weight compared with that of a like volume of pure water, which, though practically uninfluenced by atmospheric pressure, varies with the temperature; that at 4° C, the point of utmost contraction, being taken as 1 or unity. This gives the true specific gravity, but for practical, rather than purely scientific purposes, it is found more convenient to employ, as the standard of comparison, the weight of water at 60° F. = 15.55° C., that being the usual temperature of the laboratory in temperate climates, though strictly it is not 1.00000 but 0.99910. This may be called the "apparent" specific gravity at 15.55° C.; and when in routine work the specific gravity is obtained by ascertaining the weight of a given volume of the liquid, a glass vessel being used and no correction made for its expansion, we introduce another error, and have "the apparent specific gravity at $x°$ in glass." All these differences are so small that no practical harm can result so long as one standard is adhered to, and the requisite correction is made when the corresponding temperature cannot be obtained, which is only the case in very hot weather.

It must not, however, be forgotten that the whole system of specific gravities of solids as well as of liquids is based on the *true* specific gravity of water, 1 cubic centimetre of which at 4° C. weighs one gramme.

Other temperatures are occasionally taken for special purposes, as the specific gravity of fats, which may be calculated for 100° C.

The true specific gravity may be represented as specific gravity at $\frac{a^\circ}{4^\circ}$ or $\frac{b^\circ}{4^\circ}$, and apparent specific gravity as $\frac{x^\circ}{x^\circ}$, that commonly used in dairy work and milk analysis being the apparent specific gravity in glass at $\frac{x^\circ}{15.55^\circ\ \text{C.}}$ or $\frac{x^\circ}{60^\circ\ \text{F.}}$: the full formula for calculating specific gravities being:

$$\text{Sp. gr.} = \frac{\text{Weight of a known volume of a liquid} \times \text{Sp gr. of water at the same temperature}}{\text{Weight of same volume of water at same temperature}}$$

The true specific gravity of water at certain temperatures is,

0° C. (32° F.)	0.99987	60°	0.98331
4°	1.00000	80°	0.97191
15.55° (60° F.)	0.99906	100° (212° F.)	0.95863
37.78° (100° F.)	0.99312		

To determine the specific gravity, we may find the weight of a known volume or the volume of a known weight of the liquid. For the former we fill and weigh vessels of known capacity, as the specific gravity bottles, or better still a Sprengel tube. This is a U-shaped tube, with divergent capillary branches, one of which, rather larger than the other, has a fine line etched round it. The weight of the tube when empty and dry is first noted, it is then filled with distilled water and immersed in water at 15.55° C. until the contained water has attained the same temperature, when the contents are adjusted to the mark on the larger branch by the careful application of blotting-paper to the aperture of the smaller, and after having been removed from the bath and wiped dry it is weighed. The difference between its weight when full and when empty gives the weight at 15.55° of the contained volume of *water*, and is recorded with that of the empty tube for future use. The tube is then completely filled with the *milk* under examination, immersed in the water-bath, and the same procedure gone through, when the weight of the contained milk divided by that of the same volume of water gives the specific gravity of the milk at the temperature of observation.

A tube, having a capacity of ten to twenty cubic centimetres, is most convenient, the desired temperature being obtained more quickly than with larger tubes or bottles.

The weight of a known volume of a liquid may also be determined by observing the loss of weight through displacement.

The apparatus employed is a Westphal balance, *i.e.*, a steelyard, from one end of the beam of which a glass plummet is so hung that when suspended in air, the pointer is at zero, to which point it returns if, when the plummet is immersed in water at 15.55°, the weight is hung at the other end. The beam is divided by notches into ten parts, and riders are provided weighing the same as, and $\frac{1}{10}$, $\frac{1}{100}$, and $\frac{1}{1000}$ of, the weight. The plummet is immersed in the milk to be examined, and the riders attached and adjusted until the pointer returns to zero. The method of reading is to count 1 for the weight, and then to fill up the decimal places from the first to the fourth by the numbers of the notches on which the riders $\frac{1}{1}$, $\frac{1}{10}$, $\frac{1}{100}$, and $\frac{1}{1000}$ of the weight, have respectively to be attached to bring about equilibrium, the places of the riders not required being supplied by 0. It is more rapid, but not quite so accurate, as the use of a Sprengel tube.

The volume of a known weight does not strictly speaking give the specific gravity but *its converse*, the specific volume. The lactometer is commonly employed, and though each instrument is correct at that temperature only for which it was graduated, and it is not easy to determine accurately the level of the liquid on the stem, the consequent errors in dealing with a liquid, the composition and density of which vary within such narrow limits as those of milk, are unimportant, while the practical convenience of the lactometer is so great that it is not likely to be superseded in the routine work of the dairy.

The specific gravity of milk may be described as the resultant of that of the solids not fat, which, held in solution, raise it

above that of water, and of the fat which, present in the state of emulsion or suspension, tends to lower it; but in a lesser degree, a difference of 1 per cent. in the solids not fat having an influence on the specific gravity equal to that of 5 per. cent of fat. That of individual cows may be anything between 1.0135 and 1.0397, but the mixed milk of a herd rarely falls outside the limits of 1.030 and 1.034, the average being 1.032. By the removal of the cream, consisting mostly of the fat, the specific gravity is raised, while the addition of water lowers it. By itself the specific gravity is of no value as an indication of the character of the milk, save in cases of extreme dilution; for while the addition of 10 per cent. of water to a milk of specific gravity 1.034 could not be detected, the complete removal of the fat from one of 1.032 would raise the specific gravity to 1.036, and the addition of 10 per cent. of water would bring it back to 1.032. Thus, while the specific gravity of milk very rich in fat will always be below the average, that of skimmed or separated milk will be the highest of all.

But as a preliminary step in the examination of a milk it is very useful, and should always be noted whatever be the subsequent procedure.

The specific gravity of milk being thus the resultant of two opposing factors varies within comparatively narrow limits, and the ratio of the several constituents to one another being, as a rule, so nearly constant that for practical purposes the solids not fat may be treated as homogeneous, it has been found possible to calculate the percentage of fat by a comparison of the specific gravity with the weight of total solids.

A vast amount of ingenuity has been expended in devising formulæ and working out tables for this purpose, which were very serviceable so long as the methods of estimating the fat by extraction and weighing were tedious, inaccurate, or both, but some of the more recent procedures, in which the fat is separated by centrifugalisation, or extracted without coagulation

of the casein, have rendered them really superfluous. They are based on the fact that the specific gravity of a solution of solids in water = 1 + the number of grammes of the solids in 100 cubic centimetres of the solution, multiplied by an empirical factor depending on the molecular state of the solids when in solution.

Fleischmann's formula was largely used, especially in the dairies of Schleswig-Holstein and North Germany, and agreed well with the results obtained by Soxhlet's method; as did Hehner's modification with those of the process recommended by the Society of Public Analysts. But more recently Richmond has deduced from the results of the very latest and most accurate processes, a formula preferable to those of previous workers, both for correctness and for simplicity:

T being the total solids,
G the lactometer degrees,
D the specific gravity, and
F the fat.

Fleischmann's formula was:

$$T = 0.2665 \frac{G}{D} + 1.2\ F.$$

Hehner, dropping D and modifying the coefficient, gave,

$$T = 0.254\ G + 1.164\ F.$$

Richmond approached nearer to Fleischmann with

$$T = 0.2625 \frac{G}{D} + 1.2\ F,$$

but found that it could be simplified by dropping D, and modifying the coefficient, which, as well as that of F, he expressed as vulgar fractions:

$$T = \frac{G}{4} + \frac{6\ F}{5} + 0.14$$

or, dropping the last term,

$$T = \frac{G}{4} + \frac{6\ F}{5}.$$

Even this small amount of calculation may be avoided by

the use of Richmond's Milk Scale, which consists of two parallel fixed scales, representing respectively percentages of total solids and of fat, with a sliding specific-gravity scale between them. The line corresponding to the specific gravity of the sample is brought to that corresponding to the total solids, when an arrow at the end of the sliding or specific gravity scale will indicate on the fat scale the percentage present, calculated according to the formulæ

(1) $T = 0.254\,G + 1.164\,F$; or (2) $T = 0.25\,G + 1.2\,F + 0.14$.

As a matter of fact, lactometers do not indicate specific gravities but specific volumes, as does the expression $\frac{G}{D}$; these are always less than the specific gravity, especially in the higher terms of the series, thus:

20.0	specific gravity	=	19.6	specific volume.	
25.0	,,	=	24.4	,,	,,
30.0	,,	=	29.1	,,	,,
35.0	,,	=	33.8	,,	,,

The error is, however, unimportant, and may often be neglected in averaging specific gravities calculated as usual by weights. But if the number of grammes per 100 cubic centimetres be averaged, the means of the specific gravities give correct results. The relations between specific gravities and specific volumes may be stated thus:

(1) If equal *volumes* of different milks be mixed the specific gravity of the mixture will be the mean of the specific gravities of the several milks; and (2) if equal *weights* of different milks be mixed the specific volume of the mixture will be the mean of the specific volumes of the several milks.

Since milk, like all liquids, expands with heat, all such observations should be made at, or corrected to, a temperature of 60° F. This correction, which in practice will be required only in very hot weather, may be made by means of tables, or by an addition that Richmond has adapted to his Milk Scale.

When first drawn from the cow the milk contains numerous air bubbles, giving it a frothy appearance, and the specific

gravity should therefore not be taken until these have disappeared, which they do in an hour or two; but on long standing, a slight rise in the specific gravity, averaging 0.001, occurs in a majority of instances. This phenomenon, first noticed by Recknagel, is probably due to an increase in the density of the fat globules going on during their gradual solidification.

Estimation of the Total Solids.—This can of course be effected only by evaporating the water and weighing the dried residue; but the substances of which this is composed being very hygroscopic, and at the same time liable to partial decomposition by the action of excessive heat, or even by prolonged exposure to more moderate temperatures, it is not easy to determine the precise moment at which desiccation is complete and decomposition has not begun; while at temperatures near boiling-point these processes cannot be separated, the second commencing before the former is complete.

In Wanklyn's practice of boiling five grammes in a platinum dish over a water bath for three hours, and cooling in a desiccator, some water was always retained; and this method has been generally superseded by that, approved by the Society of Public Analysts, of continuing the drying at a temperature of 100° C. till the weight remains constant, which it is held to be when further drying causes a loss of less than one milligramme per hour. The residue is, however, more or less charred, and the result not altogether satisfactory, though duplicating well, since the browning is doubtless due to decomposition with formation of formic acid, before the whole of the water has been expelled. It is, however, possible by taking not more than one gramme of milk, spreading it over a large surface, and evaporating it rapidly at a temperature not exceeding 100° C., to obtain a *white* residue of constant weight. Various accessory means have been tried for increasing the surface exposed; but while some, as sand, present no real advantage, others appear to give less trustworthy results.

Babcock's method, adopted by the Association of Official Agricultural Analysts of America, yields a perfectly *white* residue, which shows no appreciable loss of weight on prolonged drying. Richmond finds the results most satisfactory when thus carried out. A small platinum dish, in which three grammes of Italian asbestos fibre have been spread out, is strongly ignited in a muffle, cooled and weighed. Five grammes of the milk are poured over the asbestos, and the dish with its contents weighed to the nearest milligramme. It is then evaporated over a water-bath for about two hours, and afterwards in a water-oven till it ceases to lose weight.

A water-oven is preferable to a hot-air bath, for though the temperature of the air may be kept uniformly at 100° C., that of the contents of the dishes is apt to be raised somewhat higher by the heat conducted through the shelves from the walls of the chamber, which is not the case when the walls themselves derive their heat from hot water circulating through them. If a hot-air oven be used the dishes should never be stood on the bottom unless an inch of cork be interposed; for without this precaution the temperature of their contents may rise to over 130° C.

Estimation of Ash.—The weight of the total solids having been noted the residue may be incinerated by raising the crucible to a dull red heat over a Bunsen flame or spirit lamp, until a fine white ash is left; when asbestos has been used there is less risk of loss by the volatilisation of the alkaline chlorides, but the temperature should not be raised higher than is necessary for the production of an ash.

Estimation of Fat.—Save in scientific investigation it is rarely necessary to do more than determine the percentage of total solids and of fat, and, by deducting the latter from the former, to obtain that of the solids not fat, or S.N.F. as they are commonly designated. Indeed, for routine dairy work, in the detection of supplies of milk of inferior quality, whether naturally so or from having been

fraudulently watered, it is generally sufficient, at any rate as a preliminary step, to make an approximate estimation of the fat only.

The fat may be estimated by (1) gravimetric, (2) volumetric or (3) indirect methods; whatever advantages, however, the last-named may offer on the score of ease and rapidity are outweighed by their want of accuracy, while one at least of each of the former is at once as rapid and as accurate as can be desired for all practical purposes.

Gravimetric methods.—The extraction of the whole of the fat from the dried residue being impracticable, the old method associated with the name of Wanklyn has been entirely abandoned in favour of that of Adams, or some modification of it, based on the facts that when milk is dropped on to blotting-paper not only does it spread itself out over an enormous surface, but, as Vieth pointed out, the greater part of the fat remains on the surface of the paper, together with a small proportion of casein; at the same time, a small but appreciable percentage of the fat being absorbed, the use of a Soxhlet Extractor is necessary to secure accuracy, though mere maceration in, and repeated washings with, ether might suffice.

Blotting-paper, however, contains matters soluble in ether, which, being calculated with the fat, would lead to its over-estimation. These matters have been shown by Soxhlet and Richmond to be, not fatty as was formerly thought, but resinous acids combined with calcium as a base, and but slowly soluble in ether, though when set free by any stronger acids, even those of milk, easily and completely dissolved by either ether or alcohol. Stout white blotting-paper, which is much more absorbent than filter paper, may thus be rendered "fat free" by steeping in alcohol, to which 10 per cent. of acetic acid has been added, far more speedily and thoroughly than by the most prolonged washings with ether alone. The "fat free" paper of Schleicher and Schüll is convenient and trustworthy, though even it is the better for washing in ether

before use, since it yields thereto a trace of soluble matter. not resinous, but consisting of very fine fibre.

The requisite number of paper strips having been suspended by clamps from a rail, the operator, holding each by its free end horizontally, runs on to it from a pipette in a slow stream 5 cubic centimetres of a sample of one of the milks to be examined, a like quantity being run into a small vessel for the determination of its weight.

The papers are left hanging, protected from the access of flies, which would consume the fat, until dry enough to be handled, when they are rolled into coils not more than an inch in diameter, tied with a cotton thread, marked with the number of the sample, and dried for an hour at 100° C. before being introduced into the extractors. These, having been connected with upright condensers and with flasks previously dried and weighed, are filled with ether, preferably dry, to above the level of the arch of the siphon, which is thus set in action. The flasks into which the ether runs over are immersed to a depth of about an inch in a tank of water, at 50° C. or 60° C., which keeps their contents in gentle ebullition.

When the ether has thus circulated through the extractors for five hours, the coils will be perfectly exhausted. The ether is then distilled off from the fat in the flasks, which, after the expulsion of any ether vapour remaining and cooling, are again weighed. When great exactness is wanted, one "control" or blank experiment is carried out by extracting a coil without milk into the lightest of the flasks, called a "tare"; any addition to its weight representing the resinous or other matters present in the paper itself, and, therefore, common to all the coils, is deducted from the weight of "fat" yielded by each of the others. This, however, is in most instances a needless refinement, and may be omitted.

Dry ether is obtained by washing the commercial article with water, shaking up the washed ether in a flask with calcium chloride, and, after allowing it to stand over the

chloride for a couple of days, distilling it off. The apparent yield of fat when crude ether is used averages 0.06 per cent. higher than that shown by the dry.

The *modus operandi* of the simple and ingenious apparatus which goes by the name of Soxhlet, from having been first applied by him to milk analysis, though with full acknowledgment of its invention by Szombathy, consists in the automatic and continuous distillation of the ether or other volatile solvent of fat, its condensation and percolation through the mass operated on until the liquid, on reaching a certain height, is siphoned back into the flask, in which the fat accumulates until the ether returns as pure as it went over. There is no loss of ether in the process, and that in the flasks may be almost wholly recovered by distilling off the fatty residue through a condenser in the usual way.

Adams' substitution of coils of blotting-paper for Soxhlet's gypsum, as an absorbent, was a decided improvement; and the superiority of the procedure as now perfected is indisputable, but, at the Government laboratories, Bell's method, which is but a modification of the now discredited process of Wanklyn, is still employed.

The Werner-Schmid Method.—While little inferior in accuracy to Adams', this process presents the advantage of occupying far less time, owing to the coagulation of the casein, the great hindrance to the separation of the fat, being wholly avoided; the mechanical separation of the greater part of the fat by the use of blotting-paper prior to the drying of the casein in Adams' process minimises this difficulty, which in Soxhlet's own method and that of Wanklyn renders the complete extraction of the fat well-nigh impossible. In Schmid's process it does not exist at all.

Schmid used a test-tube of about 50 cubic centimetres capacity, graduated to tenths of a cubic centimetre, for which Stokes substitutes one the middle half of which is narrowed to about ¼ inch for greater accuracy of measurement of the ethereal layer. Ten cubic centimetres of the

milk are introduced, and the same of hydrochloric acid; these are thoroughly mixed by shaking, or better by swinging to avoid frothing, and then boiled, or, as Stokes recommends, the tube is placed in boiling water for ten minutes, till the liquid acquires a deep brown colour through the action of the acid on the milk sugar, while the casein is converted into an incoagulable acid albumen. The tubes are next cooled by being held under a running tap or left standing in cold water, after which, 30 cubic centimetres of dry ether are added and mixed by gentle shaking, when the tubes are placed in a rack for ten or fifteen minutes to allow the separation of the ether from the acid watery solution. Lastly 10 cubic centimetres of the ethereal solution of fat are drawn off with a pipette, evaporated, and the fatty residue weighed; the weight of this × 3 gives the amount contained in the 10 cubic centimetres of milk operated on, or 15 cubic centimetres may be withdrawn and the product × 2.

The reason for drawing off an aliquot part instead of the whole of the ether is to avoid disturbing the fluffy layer of lact-albumen (?) that lies on the plane of contact between the aqueous and ethereal solutions.

Droop Richmond finds that if the milk be diluted with an equal volume of water before the acid is added, there is little or no tendency to the formation of this "fluffy" layer; and that while calculations made from an aliquot part of the ethereal solution are a little under, those from the whole are somewhat over, the truth; since the ether dissolved in the watery solution retains a trace of the fat, and, on the other hand, the water dissolved in the zone of ether contains some of the other solids which, when the whole is evaporated are reckoned as fat. In either case, however, the error is insignificant, and is minimised by allowing a longer time for the more complete separation of the watery and ethereal solutions.

This method is specially applicable to the examination of samples of sour milk, if they be diluted with water before

the addition of hydrochloric acid and an aliquot part of the ether be used, though, lactic acid being somewhat soluble in ether, the results have a tendency to be slightly too high.

Babcock's Asbestos Method, much used in America, possesses the merit of enabling the total solids, the fat and the S.N.F., to be determined from the same sample directly and by subtraction, while it gives results practically identical with those of Adams' process. A perforated metal cylinder

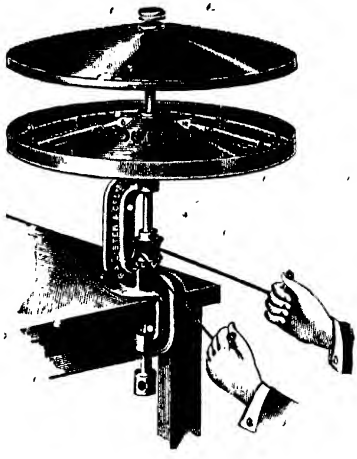


Fig. 54

60 mm. long and 20 mm. in diameter, closed 5 mm. from one end by a disc also perforated, the perforations being 0.7 mm. in diameter and 0.7 mm. apart, is loosely filled with about 2 grammes of freshly ignited woolly asbestos free from broken fragments and fine loose fibres that might fall out, is cooled in a desiccator and weighed. Five grammes of milk are introduced and evaporated at 100° C. until the residue ceases to lose weight, for determining the total solids. The fat is then removed by repeated washings with anhydrous ether or in a Soxhlet Extractor, recovered by evaporating the ether at 100° C., and weighed. The weight of the residue in the cylinder, after

drying at 100° C., to drive off the remaining ether, is that of the S.N.F., and the loss through the extraction of the fat may be taken at its weight or used to check the direct determination.

Centrifugalising as a means of separating the fat, aided by the previous solution of the casein by sulphuric acid, without which the product would be cream, not pure fat, was first employed by Babcock. Leffmann and Beam shortened the process considerably by using amyl alcohol and hydrochloric acid to facilitate the rising of the fat.

Gerber, who has given much care to perfecting this process

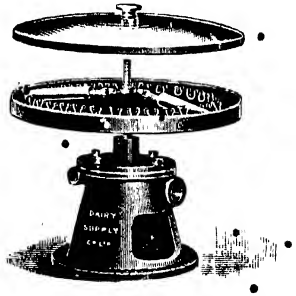


Fig. 55. Turbine Centrifugaliser or Butyrometer
Specially suited for Gerber's rapid estimation

and whose name it commonly bears, finding the addition of hydrochloric acid to the amyl alcohol quite needless, substituted for flasks stoppered bottles shaped like Marchand's lactobutyrometers, and reads off the fat at 60° to 70° C., instead of when cold.

The chemicals required are: commercial sulphuric acid, specific gravity 1.820 to 1.825, containing 90 to 91 per cent. of H_2SO_4; and amyl alcohol, specific gravity 0.8145 to 0.816 at 15.55° C., boiling at 124° to 130° C., which with an equal volume of strong hydrochloric acid should give a clear solution not darkening beyond a pale brown after 24 hours, its purity being indispensable.

Apparatus: "acidobutyrometers," glass bottles closed by india-rubber corks, their necks graduated with 90 divisions, each representing 0.1 per cent. of fat, pipettes of 11 cubic centimetres for milk, a 10 cubic centimetre *bulb* pipette for acid, a 1 cubic centimetre pipette for amyl alcohol, and a 10 cubic centimetre water pipette divided into 0.1 cubic centimetres. For cream testing some 3 cubic centimetre pipettes and a water pipette delivering 8.2 cubic centimetres are required.

Procedure: into each of the bottles arranged in the stand, run 10 cubic centimetres of the acid. Having well mixed the several samples of milk measure 11 cubic centimetres of each into the bottle bearing the corresponding number, and add 1 cubic centimetre of the amyl alcohol.

Insert the corks, shake the bottles up and down till the curd is dissolved, then invert them several times to thoroughly mix the acid in the lower bulb with the rest, and, taking them one by one from the stand, allow the contents to run into the larger portion, pushing up the corks if necessary so as to fill the graduated neck, put the bottles into the cups or sockets in the rotary machine, screw down the lid and rotate for two or three minutes, placing a Bunsen burner under the disc plate, so that the flame shall just touch it to prevent the cooling of the samples, and if the fatty layer be not quite clear, or there be any frothing, repeat the rotation, when they will be ready for reading. Holding the butyrometer up to the light adjust the cork, which is downwards, so that the bottom of the fat layer coincides with one of the marks on the neck (these are not numbered, but each fifth is somewhat longer than the others, so as to facilitate counting); and reckon the number of marks covered by the fatty liquid. Each small division corresponds to 0.1 per cent., and each of the largest to 1.0 per cent., so that, *e.g.*, if it extend over 36 divisions, the milk contained 3.6 per cent. of fat.

Creams must be diluted: thin creams, or those containing under 32 per cent. of fat, by introducing after the acid 8.2 c.c.

of water and then 3 c.c. of cream; and thick creams, or those with more than 32 per cent. of fat by dilution with *an equal weight* of separated milk which contains but 0.2 per cent. of fat previous to the addition of the water and measurement.

The earlier centrifugalisers, as Babcock's and Beimling's, were heavy pieces of mechanism turned by hand, but have been superseded by the lighter constructions of Gaertner, Hugershoff, Gerber-Lister and Stokes, which, though differing in details, are the same in principle, consisting of a "disc," or shallow, circular and slightly conical or "umbrella-shaped" box, which, with its movable lid, is mounted on a central spindle turning in a socket with ball-bearings on a short, massive frame, clamped or screwed to the edge of a heavy table or, better, a fixed slab. The bottles, or butyrometers, are arranged in it radially between pegs or in pockets, but Stokes substitutes for the loose lid a fixed cover with a large central aperture for introducing the bottles into the compartments into which the disc is divided. It is also more conical, so as to permit of the compartments being filled with warm water, thus avoiding the cooling of the fat during the process (Figs. 54 and 55).

Where steam or electric power is ready at hand rotation may be effected by mechanical means, but a yard of strong window-blind cord attached at one end to a wooden handle, wound a few times round a pulley encircling the spindle, and withdrawn by a smart pull, precisely as in spinning a top, will cause the disc to revolve for from three to five minutes, and being quite sufficient is almost everywhere preferred.

Indirect Methods.—These cannot be considered any better than rude approximations, and of use for the detection of gross dilutions only. The specific gravity as obtained by the lactometer is worthless, and often deceptive when applied to the entire milk only, but if advantage be taken of the power of filtering paper to separate the fat, and the specific gravity of the filtered and unfiltered milks be taken, the difference between them divided by 0.0008 will give the percentage of fat, and

that of the unfiltered less 1 divided by 0.004 the S.N.F.; but there is no advantage in filtering the whole of the sample, for while the filtrate of the first fifteen minutes has lost, besides the fat, traces only of the casein, a good deal of the latter fails to pass, and is retained with the fat in the later filtrates.

The Weight of Solids not Fat is usually determined by deducting that of the fat from that of the total solids, though in Babcock's Asbestos Method it, as well as the fat and the total solids, are obtained directly and on the same sample.

The separate determination of the casein, sugar, &c., is not required in ordinary dairy work, and may be studied in larger and special works on milk analysis.

Detection of Adulteration.—The nature, limits and causes of differences and variations in the composition of the milk of the several breeds and of individual cows will be considered in chapter xiv.

In the mixed milk of an entire herd, these differences tend to disappear, those above and below the average neutralising one another, and as received from the farm a normal composition may be reasonably expected, subject only to the influence of season, which affects all alike.

In fixing a standard, the percentages of fat and S.N.F. are necessarily put lower than is desirable, lower, indeed, than those met with in the great majority of samples examined, and so far it may have the effect of passing and, in a sense, legalising, or, at any rate, permitting, the watering down of milks of a higher quality. But this is unavoidable; and to convict a dealer of wilful adulteration when by the "appeal to the cow" he could prove to the satisfaction of the Court that his milk, though poor, was pure, would tend to discredit analyses in general, while the dairy companies and wholesale dealers have no difficulty in making the farmer feel that it is to his own advantage to maintain a high standard by judicious feeding and otherwise, regardless of the so-called standard or permissible minimum of the Courts.

The standard fixed by the Board of Agriculture, under the

Sale of Foods and Drugs Act, 1899, is that which was adopted many years age by the Society of Public Analysts, viz., fat 3 per cent. and S.N.F. 8.5 per cent. by weight.

For legal proceedings, however, the estimate of added water must be based on the assumption that the milk was already of the poorest, and will represent the least possible addition that could have produced the result. The formula usually employed is

$$(1) \qquad W = 100 - \frac{S.N.F.}{8.5} \times 100.$$

In the certificate the percentage of water added should be described as "*at least* so many parts per cent."

The *probable* extent of the dilution, assuming the milk to have been originally of average quality, would be given by substituting 8.9 for 8.5.

Another formula which may be used for checking the above is based on the specific gravity and the percentage of fat.

$$(2) \qquad W = 100 - \frac{G + F}{34.5} \times 100.$$

This, too, gives the least possible estimate; the *probable* addition would be found by substituting 36 for 34.5 as the sum of the specific gravity and percentage of fat in the original milk.

This formula is applicable to all milks irrespective of the amount of fat, which necessarily affects the percentage of S.N.F., whereas in normal milks the sum of the specific gravity and the percentage of fat, two factors to some extent inverse one to the other, varies only between 36.11 and 36.35, that is the sum is constant within 0.7.

Neither of these formulæ is capable of detecting the mere removal of the fat, which must be estimated by its actual deficiency, or, which amounts to the same thing, the practice that has grown of late of diluting whole with separated milk.

The *minimum* of cream removed is given by the formula:

$$C = 100 - \frac{F}{3} \times 100$$

but the *probable* abstraction by substituting 3.75 for 3, or by reference to the table (page 241) of the percentage of fat proper to the time of year.

Salt, cane sugar, or dextrin are occasionally added to restore the specific gravity lowered by watering. The salt is detected by noting the excess of chlorine above the normal 0.10 per cent., and sugar, &c., by the difference in the estimation of the milk sugar by polarisation and by Fehling's solution.

Annatto is sometimes used to give an appearance of richness to milk, but may be detected by coagulating the casein with acetic acid, washing the curd with water, and digesting with strong alcohol, which dissolves out the colouring-matter; the alcohol is then evaporated, and the residue taken up by a little water. Annatto is unchanged by mineral acids, but some of the aniline and coal tar colours turn pink.

Detection of Preservatives.—Carbonate of soda is used to correct sourness, but boric acid is the chief constituent of most of the preservatives in the market. Salicylic acid is occasionally employed, and of late "formalin," a 40 per cent. solution of formic aldehyd in water, has come into favour, as being a more powerful antiseptic, even in the small quantities that its pungent taste necessitates.

Carbonate or bicarbonate of soda is detected by the increased alkalinity of the ash, which is estimated by titrating with decinormal nitric acid, using phenolphthalein as an indicator, 1 cubic centimetre of the acid is with this indicator equal to 0.0106 gramme of Na_2CO_3, which in natural milk does not exceed 0.025 per cent. of the soluble ash.

Boric Acid or Borax.—As rough qualitative tests for boric acid preliminary to a quantitative examination the ash may (1) be slightly acidified by hydrochloric acid and a piece of turmeric paper dipped in the solution. On drying the paper will be found to be of a pinkish-brown, and when moistened with a solution of sodium bicarbonate to turn a greenish black; or (2) if strong alcohol be added to the ash previously

moistened with dilute sulphuric acid and a light applied it will burn with the green flame characteristic of boric acid. The turmeric test may serve in a rough way to distinguish between boric acid and borax, that is sodium biborate, if applied successively to solutions of the ash (1) in water and (2) in dilute hydrochloric acid, for the boric acid is free to act on the paper in either, but when combined with the alkali it can do so only having been liberated by the stronger acid: thus if both react equally it indicates boric acid; if (2) react, but (1) does not, borax; and if both react but (2) more strongly, both boric acid and borax are present.

The quantitative determination of boric acid is a somewhat difficult proceeding, but full details of the methods will be found in Richmond's and similar works.

Salicylic Acid.—Add mercuric nitrate to the milk and filter. Shake up the filtrate with ether and evaporate. Take up the residue with water and divide into three parts. To one add a drop of a dilute solution of ferric chloride, when, if salicylic acid be present, a violet colouration is produced; to the second add bromine water, when a yellow curdy precipitate occurs and the odour of a halogen is perceived phenol compounds may be recognised; and the third is to be evaporated to dryness with strong nitric acid, and the residue dissolved in a few drops of water, when on the addition of ammonia a yellow colouration is produced. Phenol and other similar derivatives of benzene give the like reactions, but as they are not likely to be present, salicylic acid may confidently be assumed to be the cause.

Formaldehyd.—The tests for this are numerous, some being characteristic. The best, perhaps, are Hehner's and Vanino's, neither of which, though characteristic and extremely delicate, is in any way quantitative, for the respective reactions do not appear when a large amount of formaldehyd is present; this peculiarity, however, is no defect, since its pungent taste precludes its use in any but minute proportions. Hehner's test is to run a little 91 per cent. sulphuric acid

into a test-tube containing some milk diluted with an equal quantity of water so that it forms a layer at the bottom, when, if formaldehyd be present, a violet blue colour appears at the junction of the liquids, and will persist for two or three days.

With pure milk a greenish tinge appears at the plane of junction, and after some time a brown colour below it. Pure sulphuric acid does not give this reaction, and the commercial acid containing traces of iron chloride and oxydising agents should be used. It will easily detect one part in 200,000 of milk. In Vanino's phloroglucin test we have one of even greater delicacy, since it gives a perceptible tint with one part of formaldehyd in 25,000,000. The deepest red is obtained in solutions of from 0.5 to 0.00004 per cent., *i.e.*, one part in from 200 to 2½ millions, but only a rose colour in those of 3 per cent.. and none, or scarcely any, in solutions of 10, 20, or more per cent.

Domestic Tests for certain colouring-matters and preservatives.—Let some milk stand in a glass vessel till the cream rises: if artificially coloured the bulk of the milk, instead of being white, will be of a deeper yellow than the layer of cream.

Annatto.—A strip of white filter paper left for a few hours in milk to which a little bicarbonate of soda has been added will be tinged a yellowish-brown.

Coal-tar dyes.—A little of the milk added to a drop of sulphuric acid in several of water on a white saucer, and stirred with a glass rod, will show a beautiful pink colour.

Boric acid.—To ½ oz. of the milk in a glass add a few drops of phenolphthalein and of caustic soda, drop by drop, stirring till a pink colour appears. Then divide the milk equally between two test-tubes, adding to one an equal volume of water and to the other a mixture of equal parts of pure glycerine and water. If the milk be pure no change will occur in either tube, but if boric acid (or borax) be present the colour in the former will become gradually darker, and in the latter will fade away.

CHAPTER XIV

CONTROL OF ADULTERATION

The composition of milk being naturally subject to considerable variations, depending on the breed, age, food, &c., of the cows, the season and weather, and perhaps other conditions, there are great difficulties in the way of fixing a standard which shall neither be so high as to condemn many genuine milks, the comparative poverty of which is owing to causes beyond the control of the farmer, nor so low as to offer an inducement to the dilution of milks of more than the average, though not of extraordinary richness.

The fat is the constituent that varies most, and to which most importance is attached by dairy chemists and by the general public.

The standard of the Society of Public Analysts now adopted by the Board of Agriculture is 3 per cent. of fat and 8.5 per cent. of solids not fat, making a total of 11.5 of total solids. This is, however, to be regarded as the minimum permissible, and not as a standard that need not be exceeded. At present it must content the magistrate, but should not satisfy the vendor or the consumer.

It cannot be denied that the milk of breeds as the Dutch and Frisian cows not unfrequently falls below this very moderate standard, and that cows of other breeds, if left to pasture themselves in cold wet weather, or throughout prolonged droughts, may temporarily yield a milk of very poor quality; but these are preventible conditions, and the

farmer must not plead in extenuation his want of judgment in selecting his stock, or his neglect to supplement a starvation diet with more nutritious additions of cake, meal, &c. Nor is it permissible to adduce in defence, on the authority of analysts, instances in which the milk of single cows has fallen short of the standard, since it is only in the case of "special" kinds, as so-called "Nursery" milk, that that of individual cows is kept apart. Dairy milk, as sent to town and as retailed to the public, is always the mixed milk of an entire herd of, as a rule, 20 to 40 animals, and in the larger town establishments for its distribution the milk of several or of many herds undergoes a further admixture, ensuring a uniformly good average of composition.

While it would be unfair to fix a standard so high that, however desirable and, indeed, attainable by great care and free expenditure, it might easily be, at times at any rate, beyond the power of the poorer farmer to secure, the danger inseparable from a low standard is the inducement it holds out to the trade to increase the volume of milk by diluting the richer, so far as can be done, without overstepping the line.

The older form of falsification was the dilution of the milk with water. This, if carried beyond a very limited extent, is easily detected by the reduction in the percentage of solids not fat, which, being far more constant than that of fat, betrays the addition of water, when the fat, being still well above the 3 per cent., would give no indication.

The modern method of adulteration, and one far more difficult to determine, is to dilute with separated milk; thus preserving the due percentage of solids not fat unchanged, while bringing down that of fat so far as can be done with safety. Such a procedure might bring out a milk with fat 2.5 and solids not fat 9.5 per cent. On the strength of the latter it would be impossible to maintain

that water had been added; but the low percentage of fat would be highly suggestive of the addition of separated and fatless milk, and if it were thus brought down to 2.0 per cent., though the total solids would still be up to the normal, and it would be impossible, indeed, evidently contrary to fact, to say that any quantity of water had been added, such milk could nevertheless be rightly described as "not of the nature, quality, and description expected by the purchaser."

A milk should not be pronounced "watered" on the strength of the percentage of fat alone, nor on that of the solids not fat alone unless these are well below 8.5 per cent.

The triple standard is perhaps the safest for estimating the value of these solids, apart from the fat. It is 8.5 of solids not fat, 0.5 of nitrogen, and 0.7 of ash per cent. on these solids.

This relation between the nitrogen and salts and the solids not fat is in most instances maintained even when the solids happen to be below 8.0 per cent. It is true that the ash may be raised by the addition of salt and boric acid as a preservative, but boric acid is a foreign body, and the chlorine in natural milk rarely exceeds 0.1 of the salts.

In 253 samples of genuine milk having from 8 to 10.5, or, omitting this single extreme instance, 8 to 9.7 per cent. of solids not fat. Droop Richmond found the percentage of ash to solids not fat to average 8.3, the highest being, as a rule, in those with the lowest solids and *vice versâ*, and the extreme to be 7.9 and 9.5, or in one of those having but 8 per cent. of solids 10 per cent. was ash.

Dr. Vieth's estimates of the fat in the milk of individual cows are unrivalled in number, and particularly valuable as showing the range of variation in different breeds, while from the methods employed being very accurate, though not the most recent, they are more trustworthy than those of Dr. Bell. They bring out clearly the greater variability of

the percentage of fat in the milk of Shorthorns and the high uniform richness of that of the Jerseys.

Percentage of fat	Dairy Shorthorn	Pedigree Shorthorn	Kerry.	Jersey.	Red Polled.	Other Breeds.	Total.
ABOVE THE STANDARD OF THE BOARD OF AGRICULTURE							
Above 10	1	—	2	—	—	—	3
8-10	10	—	6	11	—	1	28
7-8	11	3	17	36	—	4	71
6-7	76	8	111	113	6	21	335
5-6	382	91	408	136	41	45	1103
4-5	1313	594	659	89	70	70	2795
3·5-4	625	362	182	14	31	43	1257
3.0-3·5	309	173	84	3	26	34	629
--	2727	1231	1469	402	174	218	6221
BELOW THE STANDARD OF THE BOARD OF AGRICULTURE							
2.9	28	15	6	—	6	4	59
2.8	25	15	7	—	1	5	53
2.7	21	8	7	—	2	3	41
2.6	16	10	2	—	2	1	31
2.5	5	5	—	—	1	—	11
2.4	8	5	1	1	—	1	16
2.3	5	1	—	—	—	2	8
2.2	2	—	—	—	—	1	3
2.1	5	1	—	—	—	1	7
2.0	2	—	—	1	—	—	3
1.9	2	1	—	—	—	—	3
1.8	—	—	1	—	—	—	1
1.7	—	—	—	—	—	1	1
1.6	1	—	—	—	—	—	1
1.5	—	—	—	—	—	—	—
1.4	—	—	—	—	—	1	1
1.3	1	—	—	—	—	—	1
1.2	—	—	—	—	—	—	—
1.0	1	—	—	—	—	—	1
—	122	61	24	2	12	20	241
G. totals	2849	1292	1493	404	186	238	6462

The percentage of samples failing to come up to the standard of 3.0 per cent. of fat were for each breed: Jersey, 0.49; Red Polled, 6.4; Kerrys, 1.6; Shorthorns, 4.4; other breeds, 8.4.

Dr. Vieth gave a similar table of the solids not fat in different breeds:

Percentage of fat	Dairy Shorthorn	Pedigree Shorthorn	Kerry.	Jersey.	Red Polled.	Other Breeds.	Total.
COMING UP TO THE STANDARD OF THE BOARD OF AGRICULTURE							
Above 10	21	—	6	15	2	7	51
9.5–10	112	37	88	91	16	47	391
9.0–9.5	972	390	744	200	69	114	2489
8.5–9.0	1491	734	594	91	76	59	3045
—	2596	1161	1432	397	163	227	5976
FALLING SHORT OF THE STANDARD OF 8.5 PER CENT.							
8.4	108	70	23	2	6	6	215
8.3	62	30	22	2	7	2	125
8.2	36	9	6	2	—	1	54
8.1	12	9	3	1	—	1	26
8.0	15	7	—	—	3	—	25
7.9	10	2	2	—	1	1	16
7.8	5	1	—	—	—	—	6
7.7	3	2	—	—	2	—	7
7.6	—	1	1	—	—	—	4
7.5	—	—	—	—	2	—	2
7.3	—	—	—	—	1	—	1
7.1	—	—	—	—	1	—	1
6.6	—	—	1	—	—	—	1
6.2	—	—	1	—	—	—	1
6.1	—	—	1	—	—	—	1
4.9	—	—	1	—	—	—	1
—	253	131	61	7	23	11	486
G. totals	2849	1292	1493	404	186	238	6462

These figures represent the number of samples of milk examined, not the number of cows of each breed, and all those having less than 7.0 per cent. of solids not fat were given by the same cow.

In June 1887 her milk was good and normal, the percentages of fat and of solids not fat having been on the evening of the ninth 4.9 and 9.1, and on the following morning 3.8 and 9. But in July the proportions were reversed, the percentages at the consecutive millings on the evening of the 11th and morning of the 12th and on the evening of the 13th and morning of the 14th 9.4 and 4.9, 10.5 and 6.2, and 4.9 and 6.1, and 8.2 and 6.6. A year

later she had returned to the normal ratio of 6.3 and 8.8 and 3.2 and 8.9 on the evening of November 11 and morning of November 12, 1888, or taking the means of the fat in each evening and morning milking we have in June 4.35, in July 9.95 and 6.55, and in November of the following year 4.75.

Such an anomalous case is almost unique, and cannot be explained; still the possibility should be borne in mind.

Dr. Bell gives the following averages for different breeds:

Breed.	Total Solids	Fat.	Solids not fat.
Sussex	12.31	3.39	8.92
Welsh	13.55	4.40	9 15
Guernsey	14.46	5 16	9.30
Jersey	14.65	5.43	9.22
Kerry	13.54	4 67	8.37
Devon	13.11	3 43	9 68
Dutch	12.40	3.75	8.65
Ayrshire	13.46	4.24	9.22
Shorthorn	12.78	3.92	8.86

When the mixed milk of a herd has been examined, the fat has rarely, if ever, been found below 2.8, but when it is divided among a number of churns for despatch by rail, considerable variations may be observed owing to the unequal distribution of the fat which, not being in solution, begins to separate early. Droop Richmond gives the following results of the examination of two series of three churns, each series being derived from the same source:

	SERIES I.			SERIES II.		
Specific gravity	1.0345	1.0340	1.0320	1 0325	1.0320	1.0310
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Total solids	11.28	11.66	14 16	11.22	12.42	13.42
Fat	2.10	2.50	5.10	2 60	3.70	4.80
Solids not fat	9.10	9.16	9.06	8.62	8.72	8.62

The seasonal variations, which with their causes have been discussed in the chapter on the physiology of milk, should be taken into account by the analyst in judging of the purity of any particular sample submitted for examination.

MEAN MONTHLY AVERAGES OF MILK.

Droop Richmond gives the mean monthly composition of each as observed in the year 1901 :

Average Composition of Milk for 1902

Month	Morning Milk				Evening Milk				Average			
	Specific Gravity.	Total Solids.	Fat	Solids not Fat.	Specific Gravity	Total Solids	Fat	Solids not Fat.	Specific Gravity.	Total Solids	Fat	Solids not Fat.
January	1.0,23	12.66	3.70	8.96	1 0321	13 02	4.06	8 90	1.0322	12 84	3 88	8.96
February	1 0324	12.61	3 69	8 97	1 0322	12 95	3 97	8.98	1 0323	12.78	3 81	8.97
March	1 0,23	12 46	3 53	8.93	1 0321	12 88	3 93	8 95	1.0322	12 67	3.73	8 94
April	1.0324	12.47	3 53	8 94	1 0321	12 8	3 90	8 93	1 0323	12.65	3 71	8.94
May	1.0326	12.42	3 37	8 95	1 0322	12.87	3 91	8 96	1.0324	12 59	3 64	8.95
June	1.0325	12 20	3 29	8 91	1.0319	12.66	3 79	8 87	1.0322	12.43	3.54	8 89
July	1.0320	12 28	3.45	8 83	1.0315	12.60	3 82	8.78	1.0318	12.44	3 64	8 80
August	1.0316	12.35	3 58	3 77	1.0311	12.78	4 05	8 73	1.0314	12.57	3 82	8.75
September.	1.0320	12 54	3 67	8 87	1.0310	12.97	4.10	8.87	1 0318	12.76	3 89	8 87
October	1.0323	12 81	3 84	8.97	1.0319	13.19	4.23	8.96	1 0321	13 00	4 03	8 97
November	1.0322	12 82	3.87	8 95	1.0318	13.14	4.21	8.93	1.0320	12 98	4.04	8 94
December	1.0323	12.90	3.91	8.99	1.0318	13.10	4.24	8.95	1 0321	13 05	4.08	8.97
Average	1.0322	12 54	3.62	8.92	1.0319	12.92	4 02	8.90	1.0321	12 73	3 82	8.91

The uniformity at any given period of the composition of the *mixed* milk of many cows of different breeds is remarkable.

The evening milk is generally richer than that of the morning's milking from the fact of the cow having eaten more during the day than in the night.

Variation during act of milking.—The "first drawn or "fore" milk is always the poorest, especially in fat, while in the last drawn or, "strippings," it is not rare to find 10 per cent. of fat, indeed, "strippings" are occasionally sold as cream. Boussingault gives the following analysis of six successive portions taken from one cow at the same milking:

Portion.	1	2	3	4	5	6
	per cent.	per cent.	per cent.	per cent.	per cent.	per cent.
Total solids . .	10.47	10.75	10.85	11.23	11.63	12.67
Fat . . .	1.70	1.76	2.10	2.54	3.14	4.08
Solids not fat .	8.77	8.99	8.75	8.69	8.49	8.59

Through nervousness or restlessness as among strangers, a cow may hold back her milk, which, under such circumstances, contains often extraordinarily low percentages of fat.

The difficulty incident to the strict adhesion to a standard from the indisputable fact that some cows do occasionally, if not habitually, yield a milk that comes short of that standard in the percentage of fat or of total solids, is hypothetical rather than real, and the result of the so-called "appeal to the cow" in favour with some magistrates and assented to by certain analysts, should be merely the taking out of the summons under another section of the Act, since such milk, though it have not been fraudulently watered, and have been drawn in its actual state from the cow, is "not of the nature, substance, and quality demanded or expected by the purchaser"; and if a farmer or dairyman be so unfortunate as to possess such an animal, he should prepare it as soon as possible for the butcher, but in the meantime he should, and indeed he would, but for the purpose of defence when summoned, mix its milk with that of the whole herd, or even of some of the best, in which its influence would be negligible.

The result of a low standard is to give a certain official sanction or permission to dilution; to level down the general quality till it approaches the minimum allowed; and that this is done by some vendors was amusingly shown in an instance reported by Dr. Meredith Richards, of Croydon, one of whose inspectors, stopping a cart in the street and demanding a sample, was told by the carman that he had only skimmed milk, though the analysis showed that the milk was well up to the legal standard, having been diluted to a safe

degree only, though the vendor was afraid that he might have gone too far.

The question of preservatives is one on which there is much difference of opinion, and experts are constantly called on to state when the addition of such chemicals is or is not injurious to health. It is not, however, a matter of much importance whether the single dose of boric acid, or formic aldehyd, or even the continuous ingestion of such doses, is in itself a danger to health, but whether milk so treated as to afford no palpable evidence of souring or decomposition is wholesome. No reagents can be added in quantities sufficient to render the milk really sterile, and this being admitted, it follows that it will continue to undergo changes, which, though not evident to the eye or the taste, cannot but render it more or less unwholesome. Clean milk, refrigerated immediately after it has been drawn from the cow, will remain perfectly sweet and wholesome for fully twenty-four hours, but under no circumstances should it be sold as milk after that period has elapsed. Adults who drink but little milk may not suffer from the effects of the preservatives, or of the changes that will take place notwithstanding their presence, but infants are extremely sensitive to both, and the milk that constitutes the sole or chief article of their diet must be absolutely fresh; or if that be unattainable, it should be sterilised by heat while fresh.

LEGAL PROCEEDINGS FOR ADULTERATION

Prosecutions for dilution of milk, or for selling milk from which a part of the fat has been removed, unless as "skimmed" or "separated" milk, may always be taken under Secs. 6 and 9 of the **Sale of Foods and Drugs Act, 1875**, since the injury to health required by Sec. 3 can rarely be proved. Sec. 6 enacts that, save under conditions that do not apply here, no person shall sell any food which is "not of the nature, substance, and quality" demanded,

under a penalty not exceeding £20; and sec. 9 that no person shall, with intent that it shall be sold in that state, and without notice, abstract from any article of food any part so as to impair its quality, &c., or sell the same without disclosing the alteration, under a penalty not exceeding £20. [These penalties have been increased under the Act of 1899.]

Sec. 13.—Any Medical Officer of Health, Sanitary Inspector, Inspector of Weights and Measures, or of Markets, or police constable acting under the authorities appointing them, may procure samples . . . to be submitted to the analyst of the district; or if there be none, to some other public analyst, and receive from him a certificate of the result of his analysis.

Sec. 14.—The purchaser shall immediately notify to the seller his intention of submitting it to the *public* analyst, and offer to divide it into three parts, securely sealing each part, deliver one to the seller, retain one himself, and forward one to the public analyst.

Sec. 16.—If the analyst reside beyond two miles, the sample may be sent by post as a registered letter or parcel.

Sec. 17.—If any officer, inspector, or constable, asking for a reasonable quantity of any food, &c., sold in the shop tender the price thereof, the seller refusing to serve him shall be liable to a penalty not exceeding £10.

N.B.—If the purchaser neglect any of the formalities prescribed by secs 14 and 15, especially the mention of the "*public* analyst," the summons will be dismissed.

[Since the inspectors are probably known by sight to the seller, and police constables may be looked on with suspicion, and served with genuine articles even at less than their proper price, it is usual to depute some other person or child to ask for the article, the officer waiting outside and entering and claiming the article the moment the ostensible purchaser is served, when he proceeds as directed in secs. 14 and 15.]

Sec. 20.—If the analyst certify to a violation of the Act,

the person causing the analysis to be made may proceed for the summary recovery of the penalty before any Petty Sessional Court in the place where the article was sold.

Sec. 21.—The analyst's certificate shall be *primâ facie* evidence for prosecution, but the defendant may require the analyst to be called and examined, and may tender himself or his wife to give evidence on his own behalf. The portion of the article retained by the prosecutor shall be produced in court.

Sec. 22.—The justice before whom the complaint is made, or the Court before whom an appeal is heard, may, at the request of either party, at their discretion, cause one portion to be sent to the Board of Agriculture to be examined by their analysts, whose certificate shall be returned to the Justices, the expenses being paid as they may by order direct by the complainant or by the defendant.

Sec. 23.—Any person convicted by any justices may appeal to the next Court of General or Quarter Sessions held for the same place, on entering within three days with two sufficient sureties into his recognisance to abide by the decision of the Court and to pay the costs.

The Sale of Foods and Drugs Act, 1899.

Sec. 4.—Empowers the Board of Agriculture to fix standards and to define the extent of permissible deficiency of any normal constituents of milk, butter, cream, cheese, &c.

Sec. 9.—Requires every one selling milk or cream in a street or public place to have his name and address conspicuously exposed on his vehicle, stall, &c., under a penalty not exceeding £2.

Sec. 10.—Authorises the taking of samples in course of transit, and with consent of the purchaser or consignee, (**Sec. 14**) of delivery.

Sec. 16.—Imposes on persons obstructing or bribing an inspector a fine of £20 for the first, one not exceeding £50

for the second, and not exceeding £100 for each subsequent offence.

Sec. 17.—Revises the penalties under the previous Act, imposing in all cases where that for the first offence is £20, fines not exceeding £50 for the second, and £100 for the third and subsequent offences, and in those for which the penalty is over £50, the offence involving *personal* act, default or culpable negligence, for which the Court may deem a mere fine an insufficient penalty, authorises the substitution of imprisonment not exceeding three months.

Sec. 19.—Proceedings must be taken within 28 days of the purchase; and the summons, giving the name of the prosecutor, the particulars of the offence, and a copy of the analyst's certificate, shall not be made returnable within 14 days from service.

Secs. 25, 27 and 28 of Act of 1875 amended by **Sec. 20 of Act of 1899.**—If defendant can prove to the satisfaction of the Court that he bought the article in the same state as he sold it, and with a written warranty which he had no reason to suspect, he shall be discharged, but shall be liable to pay the costs incurred by the prosecutor, unless he have given him previous notice of his defence. He shall be able to recover from the person supplying him, in addition to any other damages, the amount of the costs, &c., incurred by him, and all further proceedings following his discharge may be taken before a Court having jurisdiction in the district where the sample was purchased for analysis, or where the warranty was given. [This is to facilitate the prosecution of the original offender by dispensing with the necessity for a change of venue.] The penalties for false warranties, whether given by principal or agent, in writing, are £20, £50, and £100 for the first, second and subsequent offences respectively, and that for *forging* a certificate or warranty, or uttering the same knowing it to be forged, is imprisonment not exceeding 2½ years with hard

labour. [The *onus probandi* of innocence is transferred to the defendant, the prosecution being no longer required, as under sec. 27 of the Act of 1875, to prove that the defendant had reason to believe the warranty or certificate to be false.]

CHAPTER XVI

BACTERIOLOGICAL EXAMINATION OF MILK

If milk were drawn from the udder under strictly aseptic conditions, it would be perfectly sterile, and it is quite practicable by the exercise of great care and cleanliness to obtain it with very few bacteria indeed. But the bacteria introduced by the hands of the milker, from the skin of the udder, the dust and air of the shed or yard, and the sides of the vessels in which it is received, and multiplying apace during the whole period of transport and exposure for sale, average in the shops 2,000,000 to 4,000,000, or indeed, in some localities, ten times these numbers in each cubic centimetre, though on leaving the dairy they might perhaps have amounted to a few thousands only, or tens of thousands at most. Some notion of the significance of these numbers, viewed simply as numbers, and assuming them to be for the most part innocent, or at least not those of specific diseases, may be formed by comparing them with those found in water. A good drinking water from a well not exposed to pollution or supplied to the public after filtration on a large scale, whether the source be from wells, upland moors or even rivers such as the Thames, will contain in each cubic centimetre 25 to 50 at the most, 100 being held in Germany to warrant its being withheld for further filtration. Unfiltered river waters may contain any number between hundreds and thousands, but for millions one must go to sewage effluents.

Mere numbers have their influence, since there will probably be some proportion of noxious germs amongst those which

are indifferent, unless the enormous multiplication of the latter has led to the extinction of the former. Since one cannot guess, as one may with waters, the probable number of bacteria, which, in a given sample, may be thousands or millions, one must begin, as in examining sewage, by diluting the milk with boiled water, and make numerous plate cultures. Four dilutions are usually made, A, containing 1 cubic centimetre of the milk to 9 cubic centimetres of water, or one in ten; B, by adding 1 cubic centimetre of A to 9 cubic centimetres of water, gives a one per cent. dilution; and C and D, each made by the deci-dilution of the previous one, represent dilutions of 0.001 and 0.0001, or one in a thousand and one in ten thousand respectively. Only in the latter, C and D, are the numbers likely to be such as to admit of enumeration.

A number of gelatine and agar plates should be made with these and incubated at a temperature of 37° C. for twenty-four hours. This is necessary since milk always contains a much larger number of microbes requiring the temperature of the living body than does water; thus at a temperature of 20° C. (68° F.) the streptococcus of most frequent occurrence grows but slowly and is easily crowded out, though found without difficulty in free dilutions and at the temperature of the living animal, which is obviously indispensable for those that are strictly parasitic in their habits.

For the **Quantitative Examination**—"One pound of finely chopped *lean* beef in one litre of freshly distilled water should be slowly heated in a water-bath to 60° C., kept at that temperature for ten minutes and quickly heated to 100° C., then filtered and made up with distilled water to one litre. Ten grammes of *Witte's* peptone and five grammes of common salt are carefully worked up with the broth a little at a time, then 100 grammes of the *best French* gelatine are added, and the mixture poured into a flask, which is kept in a steam steriliser until the solution of the gelatine is complete, to aid

which the flask should be taken out and well shaken every ten minutes. It is next neutralised by $\frac{N}{10}$ NaOH, using litmus paper as an indicator, then cooled to 50° or 55° C., the white of an egg added, well shaken, and returned to the steriliser for half an hour, filtered through *papier chardin*, and poured into sterile test-tubes, 10 cubic centimetres in each, which are then plugged with sterilised cotton-wool and placed in the steam steriliser for twenty minutes. The sterilisation is repeated on two successive days, the tubes being meanwhile kept in the ice-box. To melt the gelatine the tubes are placed in a water-bath for ten minutes at 40° C., and to each some of the water is added and mixed by swinging, not shaking, which would give rise to bubbles, and their contents poured into Petri dishes standing on ice, the lids being lifted no higher or longer than is necessary. With a 1 cubic centimetre pipette graduated to tenths, the gelatine plates are inoculated in pairs with 0.1, 0.2, 0.3 and 0.5 cubic centimetre of the 0.001 and 0.0001 dilutions of the milk and incubated at 37° C. for three days when the colonies are enumerated."*

Qualitative Examination—Tubercle Bacilli.—The sample of milk having been well stirred and shaken, some of it is poured into a sterile tube with an india-rubber stopper, and centrifugalised until the cream has separated in a thick layer. By a little careful manipulation this may be removed and set aside on a sterile dish. By quickly inverting the tube the skimmed milk is run off, leaving the slimy sediment adhering to the bottom.

The sediment and the cream are then spread separately on a number of clean coverslips, which are allowed to dry. They are then flamed, immersed for five or ten minutes in absolute alcohol, washed in ether for five minutes, immersed in alcohol to remove the ether, and the alcohol washed away in water. The complete removal of the fat is absolutely necessary for the successful staining of the tubercle bacilli.

* "Health Officers' Pocket Book," 2nd ed. pp. 198, 199.

The best method of staining is a modification of the **Ziehl-Nielson**, or **Honsell's**.

Ziehl-Nielson's process.—For this the preparation is stained for five minutes in hot (60° C.) fuchsin-carbol, and well washed in water. It is then washed in alcohol till every trace of stain that can be removed has disappeared, and again washed in water.

It is next immersed in 25 *per cent. sulphuric acid for five seconds*, again washed in water, and lastly, counterstained for three seconds in carbol-methylene blue, washed, dried, and mounted for examination.

Honsell's process.—After staining, as in the former method, with carbol fuchsin, and washing in water, it is dried.

It is then immersed in *acid alcohol* (absolute alcohol, 97 per cent.; HCl., 3 per cent.) *for ten minutes*, and washed in water, counterstained for several seconds in equal parts of a saturated alcoholic solution of methylene blue and water, again washed in water, dried and mounted.

Many bacilli which by other methods might have been mistaken for those of tubercle are thus decolourised.

The utmost care must be given to each stage of the operations in order to ensure the freedom of the preparation from fat, the action of the stain on the bacilli and its subsequent complete removal from the rest of the preparation, for if any part of the process be performed incompletely or in a slovenly manner, other bacilli, retaining more or less of the stain, may easily be mistaken for those of tuberculosis. The slightest trace of red retained by the ground in any part of the field deprives the appearance of red stained bacilli in its vicinity of all significance.

If the characteristic bacilli be present, further examination is needless, and if there be also many pus or blood cells, there can be no doubt as to the disease being seated in the udder, and the milk must be condemned as unfit for human consumption, or, indeed, for that of any animal, unless it be previously boiled.

The failure to detect the bacilli must not be taken as proving the freedom of the cow from the disease or even of the milk from the bacilli, since the portion examined can but be a minute fraction of the whole. The fact should be simply stated as such, having no more value than attaches to negative evidence generally.

Milk, like all animal fluids, contains a certain but variable number of leucocytes, but though any line between the permissible and the excessive in such a case must be arbitrary, it may be safely taken that twenty or more within the field of a one-sixth objective are very suspicious of, at least, a chronic inflammatory process. The sediment from some milk is, in fact, indistinguishable from the contents of an abscess, and the very thought of drinking milk containing measurable quantities of pus is disgusting.

Inoculation often succeeds where microscopic examination fails to detect the presence of tubercle bacilli. Some of the centrifugalised deposit is injected into the subcutaneous tissue of the groin or into the peritoneal cavity of a healthy guinea-pig, and the animal, if it have not meanwhile died from septicæmia or other cause, is killed after the lapse of two or three weeks, when unmistakable tubercular deposits in the glands or tubercular peritonitis will be found. The death of the animal within a few days of the injection must not be ascribed to tuberculosis, being caused by some other bacteria in the deposit, pathogenic to the guinea-pig. If the presence of such disturbing bacteria be known or suspected, it will be well to submit the sediment for ten minutes to a temperature of 56° C., which the tubercle bacilli are capable of resisting, though others are thereby killed or rendered inert.

It is useless to attempt the centrifugalising of any milk in which even incipient coagulation has set in, or in which, though apparently quite fluid, it is found, after centrifugalising, that the separation into three layers has not taken place as it should.

The bacillus of enteric fever must always be, or have been, present in milk that has given rise to widespread outbreaks of that disease, but the search for it is under most circumstances a waste of time. Though flourishing as an almost pure culture in the glands of the intestine, the spleen, and the blood, and leaving the body in the urine and fæcal evacuations, it is in the latter accompanied by vast numbers of the *B. coli communis*, &c., by which it is soon crowded out.

The *B. coli communis* being, however, necessarily derived from the bowels of man or beast, is in itself evidence of fæcal, and, if in large numbers, of gross fæcal pollution, and where it is that of typhoid may be also. Of course it is always present in milk as commonly supplied, being derived from the admixture direct or indirect, of cow dung; but in the event of suspicion attaching to a particular milk-supply, an examination should be made of the water used in the dairy. If this give evidence of fæcal pollution the suspicion is probably justified, and repeated search may be made in the milk for the specific organism the detection of which would be conclusive, though failure must on no account be taken as proving its absence.

The differentiation of the *B. typhosus* from the surrounding colonies of *B. coli communis* and the sub-culture of the former apart is a task requiring a delicacy of manipulation and a practical acquaintance with the behaviour of micro-organisms to which only the trained bacteriologist can lay claim, and quite beyond the sphere of the analytical chemist.

The bacteria of the typhosus group flourish best under anaërobic conditions, a special medium, and a high temperature.

The medium, Kitasato's glucose formate broth, is prepared by adding to the meat infusion, described above, 1 per cent. of the peptone, 2 per cent. of glucose, 0.5 per cent. of salt, 0.4 per cent. of sodium formate, and, after boiling and neutralising, 2 cubic centimetres of $\frac{N}{1}$ NaOH to the litre. The broth is again boiled, filtered, and put up in test-tubes, which

are sterilised by boiling for twenty minutes on that and the two following days. Anaërobic conditions are best obtained by means of Buchner's tubes, in which the tubes of broth, after having been inoculated, are incubated at 42° C. for twenty-four hours, when those showing growths are removed; this is done for two more days, after which any still sterile may be thrown away.

From these growths gelatine and, if desired, agar, plate cultures are made in the usual way, and incubated at 20° C. any suspicious colonies being from time to time sub-cultivated and worked out. In the examination of potable waters large quantities are required, and the best way of collecting the largest possible proportion of the bacteria sparsely distributed through the whole volume is to force the contents of a Winchester quart bottle through a Pasteur's filter bougie,* which is then washed out with 10 cubic centimetres of sterilised water. The bacteria in 2000 cubic centimetres are thus nearly all collected in 10 cubic centimetres, a concentration of 200 in 1, and 0.1 cubic centimetre of this represents 20 cubic centimetres of the original water.

* The best apparatus for this purpose is one made by Messrs. Baird and Tatlock from the designs of Mr. Pakes.

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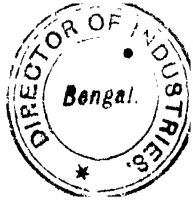

Printed by BALLANTYNE, HANSON & Co.
London & Edinburgh.